GUIDE TO THE SKY

E.A. BEET

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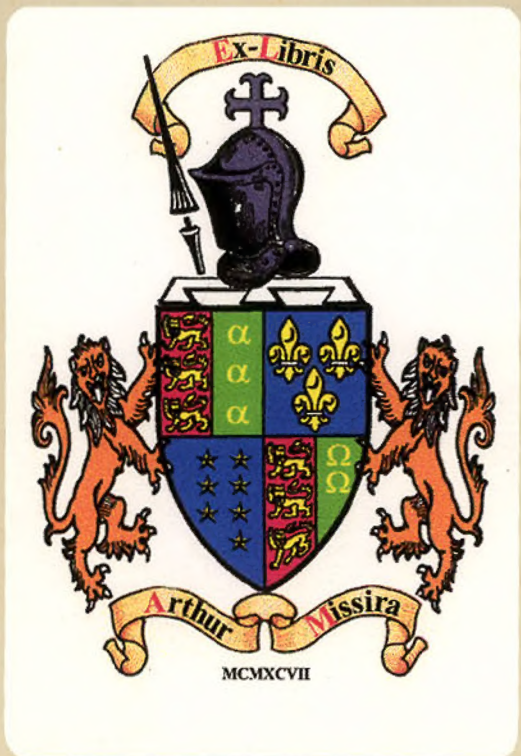

A GUIDE TO THE SKY

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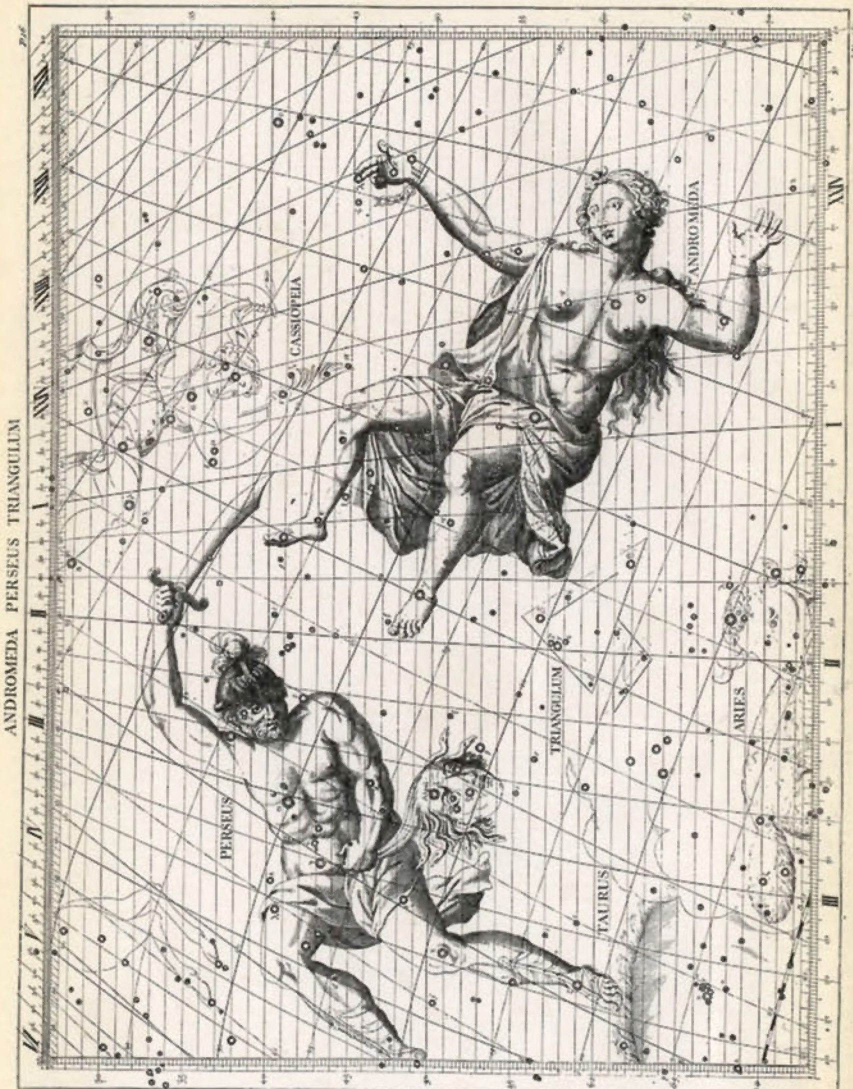

Perseus and Andromeda

A GUIDE TO THE SKY

A Practical Handbook for Beginners

BY

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PREFACE

This little book is intended to form an introduction to astronomy for practical people who are not content to read only but have a desire to do something.

Though complete in itself it does not overlap greatly with the average introductory book, and should therefore be suitable for those who have read a little as well as for the absolute beginner. It was written primarily for young people, but I hope that it will prove of interest to readers of all ages.

The first nine illustrations are from drawings by Miss L. Steele; one of the photographs is by Mr S. B. Smith; the frontispiece is reproduced from John Flamsteed's *Atlas Coelestis*, 1729.

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the *Boy's Own Paper* for permission to reproduce an article from that journal; and to the Secretary of the British Astronomical Association for numerical information.

E. A. B.

EPWORTH COLLEGE, RHYL
August 1933

PREFACE TO THE SECOND EDITION

This edition is substantially the same as the first, but the opportunity has been taken to make a few minor corrections and additions. Chapter VI has been enlarged to include a selection of books published since 1933; the list of eclipses has been extended to 1952; the table of planetary predictions, originally published in Jeans' *Stars in their Courses* in 1931, has almost expired and has been omitted. In the Appendix on Southern Stars there are now included a few objects of interest not visible from the British Isles; these are mainly taken from *Norton's Star Atlas* by kind permission of A. P. Norton, Esq. and Messrs Gall & Inglis.

E. A. B.

NAUTICAL COLLEGE, PANGBOURNE
March 1942

Once upon a time, as the story books say, there was a boy, quite young, who had a Meccano set, then a fairly new invention. He had also a pocket telescope, and with Meccano he made a stand for it. That evening, wanting something to look at with the newly completed toy, he turned it to the Moon and thus started his study of astronomy. His father taught him the names of the stars and how to find them, and gave him to read books containing wonderful pictures and descriptions of wonderful things. The boy next tried to see these things with his own little telescope—and was disappointed, for they were far beyond its reach.

Years have gone by and that boy, now grown up, has attempted to produce a book such as he would like to have had then. This is it, and it is intended to be an introduction to the study of the sky. In it you are told what to look at, when and how to look, and what you may reasonably expect to see. The writer hopes that in using it you will not be disappointed, and that when you have finished you will want to read some other books on astronomy, such as those mentioned in the last chapter.

CHAPTER I

INTRODUCTION—SOME CONSTELLATIONS

There are many beautiful scenes in this world of ours, and one of these is a clear winter night, with its thousand twinkling lights above us and the silvery stream of the Milky Way. This is specially glorious to the country dweller, away from the roar of traffic, smoking chimneys, and the glare of electric lights. Not only beautiful but interesting, for the stars have a story to tell, a story that is a remarkable blending of ancient legend and modern science.

The study of the stars is very ancient indeed, going back quite 3000 years before Christ. Many star-names are very old, and the ancient astronomers, in addition to naming them, tried to explain how they moved, as the name "Astronomy" shows, for the first part means "star" and the second part "law". Some of them, called astrologers, tried to use the stars to predict events in people's lives, which made the study of the stars a matter of great importance in those far-off days. Before a king

went to war his court astrologer would consult the stars to see what chance there was of success. When man began to sail the seas he used the stars as his guide, and even now one of the principal tasks of the national observatories is to assist navigation, both by predicting events in the sky and by providing correct time. When you hear those six little "pips", a second apart, cutting in on the wireless programme you can say to yourself "there is the astronomer at work", for the time signal comes from the Royal Observatory at Greenwich, London.

The ancient astronomers, as already mentioned, named the stars. Name them! You may think it a hopeless task to identify such an enormous number, let alone name them. It is not at all hopeless, for although there may be 100,000,000,000 stars in all, only about 3000 are visible at any one time with the unaided eye, and those which, on account of their brightness, are particularly striking number only about twenty or thirty. Not only is the number much smaller than would appear, but the brighter of them make quite distinctive patterns which, after a little practice, can easily be recognised. These groups are called constellations, and their fanciful names give an indication of their antiquity, though in many cases the group bears little resemblance

to the person, animal or object named. The names we use mainly originated in Egypt and Greece, and the people represented are the old heroes such as Hercules and Perseus, whose tales will be told in a later chapter. There are many animals in the sky—two bears, several dogs, lions, and such more fearsome things as the scorpion and the dragon. Objects, such as the crown and the scales, are not so numerous. Many of the names of individual stars, such as Altair and Aldebaran, are of Arabic origin. Besides being grouped in constellations, the stars are classified according to their brightness. The very brilliant ones are said to be of the first magnitude, the next best of the second magnitude, and so on, stars of each magnitude being about two and a half times as bright as those of the magnitude next below. Faint stars are much more numerous than bright ones, for although there are only 20 stars of the first magnitude, there are about 52 of the second, 157 of the third, and many millions by the time we reach the 17th magnitude. The unaided eye can see stars down to about the 6th, while it requires photography through giant telescopes to reach the 17th.

The sky looks very much the same to the casual eye on any clear night, the only obvious difference

being the shape and position of the Moon. A more observant person may notice and carry in mind, perhaps, some conspicuous group of stars, and if he should seek his group a few months later he may have difficulty in finding it, or even fail to find it. The sky does not remain the same; it changes not only from month to month, but even from hour to hour. This can be verified by experiment quite easily. Choose some bright star in the south, one that you will be able to recognise again, and see how far it is from some landmark such as a tree or a chimney pot. In an hour or two return to exactly the same spot and look again: the star will have moved to the right. The stars move from east to west in the same way as the Sun and Moon, and for the same reason. The daily rotation of the Earth on its axis causes all the heavenly bodies to move like this, rising in the east and setting in the west. Stand in the middle of the room and slowly turn round, towards your left: notice how objects on your left are soon in front of you, then to your right, and finally vanish from your view. Some stars move like the winter Sun, rising in the south-east, never getting high in the sky, and setting south-west. Others are like the summer Sun, rising and setting to the north of east and west and passing south high

up in the sky. Some stars never rise or set. When they descend towards the west, instead of setting they curve round close to the northern horizon, and then begin to climb up again in the east until they reach the zenith, as "overhead" is called. These stars move in circles round one called the Pole Star, once round in a day, and are therefore called the circumpolar stars; being in a northerly direction they are also called the northern stars. Just as these never set there are some that never rise in England, and to see them you must go and live in Australia, or some other place in the southern half of the world. If when turning round in your room you look straight above you, the ceiling is always in view and the floor you cannot see.

The same selected star will serve for another experiment. Look at it regularly from exactly the same place and at exactly the same time. For the first day or two little change will be seen, suggesting that although the stars do change from hour to hour they are always the same at the same hour. After a week or so you will find that this is not the case; the star has moved to the right of your landmark. Thus they change from day to day as well as from hour to hour, and in fact a star reaches the same position about four minutes earlier each

evening. In a year the daily four minutes add up to twenty-four hours, very nearly, and so the star will be back in its old position. On account of this movement the constellations occupy different positions at different seasons of the year. Why should they move like this? Your chosen star was south, so by moving to the right it gets nearer to the western horizon, and below the western horizon is the Sun, not long set. After a week or two the star has moved so far west that it is in the twilight, and very soon it becomes so near the Sun that it cannot be seen at all. When another few weeks have passed our friend may be found in the eastern twilight, rising just before the Sun. It has moved past the Sun, and further daily motion westward makes it rise more and more ahead of the Sun until at last it again becomes a feature of the night sky. Look at Fig. 1, which represents a scene from a train moving towards the right along an embankment. There is a haystack in the field, and in the distance, to the left of the stack, is a church. The view an instant later is shown in the second sketch, the church being now behind the stack, and later still it is seen to the right of the stack. Why? The motion of the train past the stack causes the distant church to appear to move to the right towards

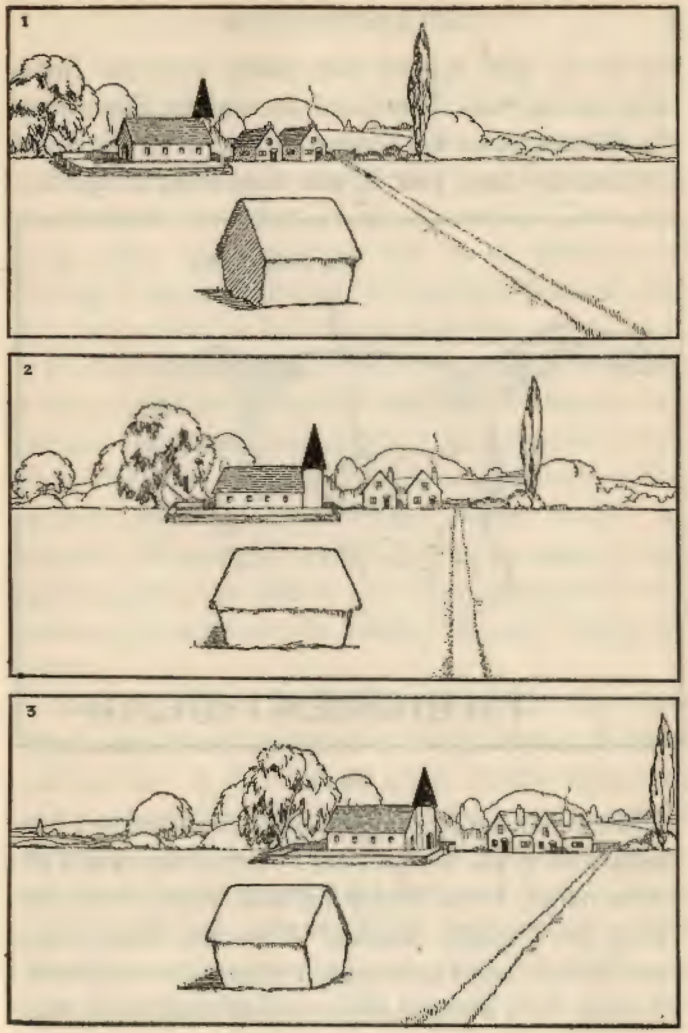


Fig. 1

the stack, past it, and then away from it. Similarly the motion of the Earth around the Sun causes the distant stars to appear to move to the right towards the Sun, past it, and then away from it.

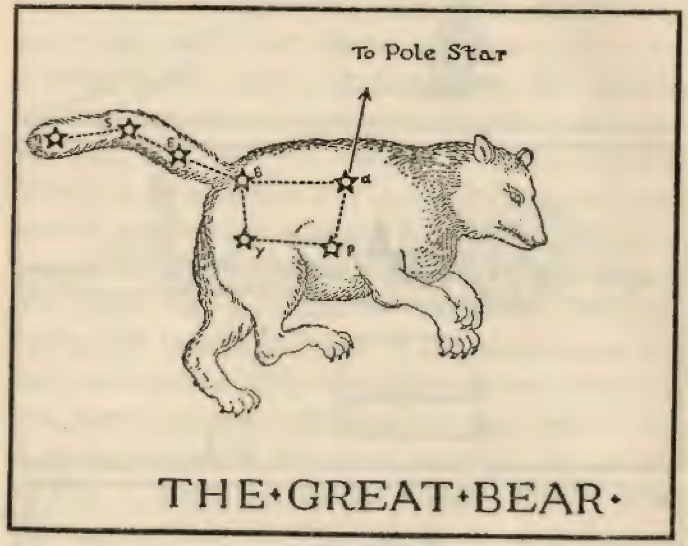


Fig. 2

The most easily recognised of the northern constellations is the Great Bear. Astronomers use the Latin name, Ursa Major (*greater* bear); it is also called the Plough, Charles' Wain, the Dipper, and the Cleaver, and I have seen it referred to as David's Chariot. It is a group of seven stars making a shape

like a saucepan with a bent handle (Fig. 2). In the autumn it is seen low in the north, the right way up. In winter it is in the east, handle downwards. In spring it is almost overhead, and then in summer it descends in the west, handle upwards. Once you have really found it there will be no difficulty in finding it again, whatever its position may be, and it is important to be able to find this group, as it is the key to many other constellations. The group looks a little like a plough, dipper, or cleaver, but there is not much bear about it. The handle represents the bear's tail, and the head and legs of the animal are made up of much fainter stars. As Charles' Wain or David's Chariot the seven stars make up the four wheels and three horses, the very faint star just above the middle "horse" being the rider.

Notice in Fig. 2 the little signs against the stars. These are Greek letters, α being alpha, β beta, and so on. A full list is given in the appendix and it is useful to remember the first seven or eight of them. In order that any star in a constellation may be referred to in books they each have a letter allotted to them, the brightest being called α, the next β, working through the alphabet until very faint ones are reached. Thus the star with the rider

is called Zeta of the Great Bear or, as the astronomer would write[1], ζ Ursae Majoris. The stars α and β are called the "pointers" because they point to that very important star, always in the north, around which all other stars seem to revolve—the Pole Star. This star is not absolutely at the pole of the sky, but the circle in which it moves is so small that its movement is not obvious to the unaided eye. You will find it by following the direction of the pointers for about four times the distance between them. As the Pole Star, sometimes called Polaris, is always in the north, it is useful to those who have to find their way in unknown country.

Between the Bear and the Pole Star (Fig. 3) are two stars fairly close together called "the Guards", and if the night is very clear four other stars may be seen, making with the Guards and Polaris a figure similar to the Great Bear. This is the Little Bear (Latin: Ursa Minor), having the Pole Star at the tip of its tail.

These two constellations are shown as bears in very ancient star maps, and there are several explanations of their origin. One of them, a Greek story, is something like this: Jupiter paid so much attention to a lady called Callisto, that his wife, Juno,

[1] Boys who say "what's the use of Latin" please note.

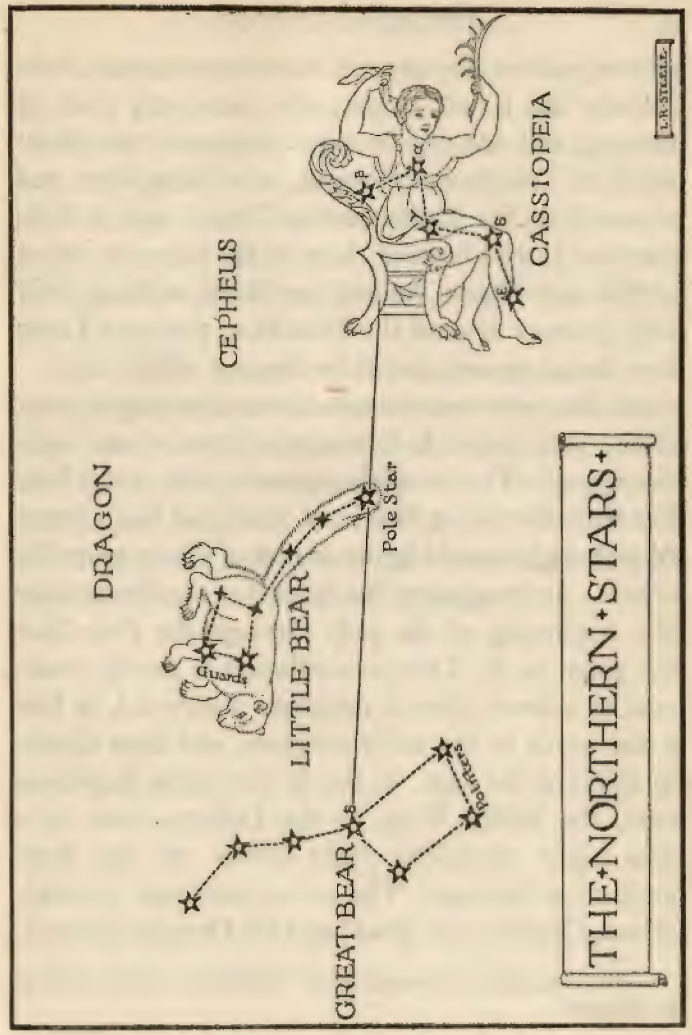


Fig. 3

became jealous and turned Callisto into a bear. Now Callisto had a son, Arcas, who was very fond of hunting, and one day he saw a bear and was about to kill it. This bear, of course, was his mother, and to save her life Jupiter turned Arcas into a little bear and placed both of them in the heavens out of harm's way. There we may see them, making their daily journey around the Pole Star, the poor Little Bear being swung round by the end of his tail.

Another prominent constellation that may be seen all the year round is Cassiopeia [pronounced *cas'-si-o-pe'-ya*][1]. This is on the opposite side of the Pole Star from the Great Bear, and is shaped like a letter W, although the old figure is that of a lady seated in a chair. An imaginary line from δ of the Great Bear (the beginning of the tail) through the Pole Star will point to it. This constellation is nearly overhead in winter, then it descends westward, is low in the north in the early summer, and then climbs up again in the east. It lies in that great luminous band, the Milky Way, or the Galaxy, seen on a clear night stretching right across the sky from horizon to horizon. The other northern constellations, Cepheus [*se'-fe-us*] and the Dragon (Draco),

[1] Pronunciations are taken from Hutchinson's *Splendour of the Heavens*.

are not drawn in Fig. 3 but the names are inserted to show where the groups are. The former is rather indefinite in outline, while the latter is a long and winding snake with a diamond of stars for the head. Cepheus and Cassiopeia were the King and Queen of Ethiopia, and these constellations, with two others, are known as the Royal Family, whose tale will be told later on.

Now before going on with the next chapter you should find the stars that never set. First the Great Bear, then, in order, the Pole Star, the Little Bear and Cassiopeia. Try and memorise these constellations, as they will be used as a guide to those which are seen only in certain seasons, and which are described in the following pages.

CHAPTER II

MORE CONSTELLATIONS

The constellations described in the first chapter can be found all the year round. Now we go on to those visible only in certain seasons, beginning with the AUTUMN STARS. In the middle of the evening, say between 8.0 and 10.0, the Great Bear will be found low in the north, while Cassiopeia, on the opposite side of the Pole Star, will be high in the sky. Imagine a line drawn from the Pole Star and passing between and twice as far as Cassiopeia and Cepheus (Fig. 4). This line will lead to a group of four stars forming a large square, well above the horizon in the south-east or south. This is Pegasus [*pe'-ga-sus*], the Winged Horse. The star forming the corner nearest to Cassiopeia does not really belong to Pegasus, but to Andromeda [*an-drom'-e-da*], which is a line of three fairly bright widely spaced stars leading away from this corner of the square and bending a little towards Cassiopeia. The two constellations together form a much magnified Little Bear. You may think the line of Andromeda is four stars, not three, but the fourth one is α of

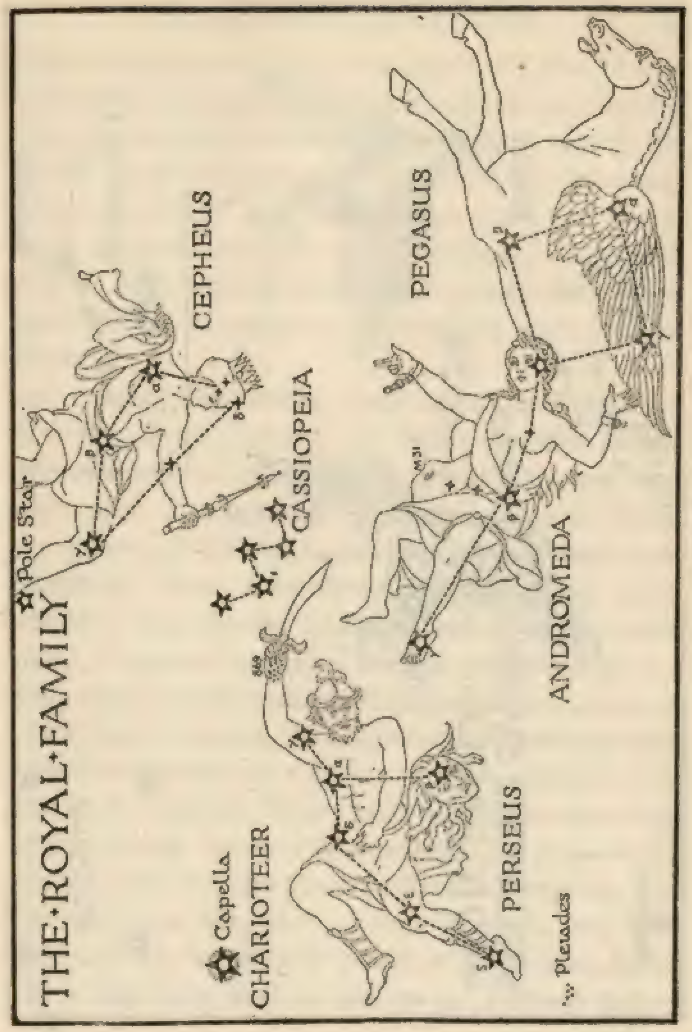


Fig. 4

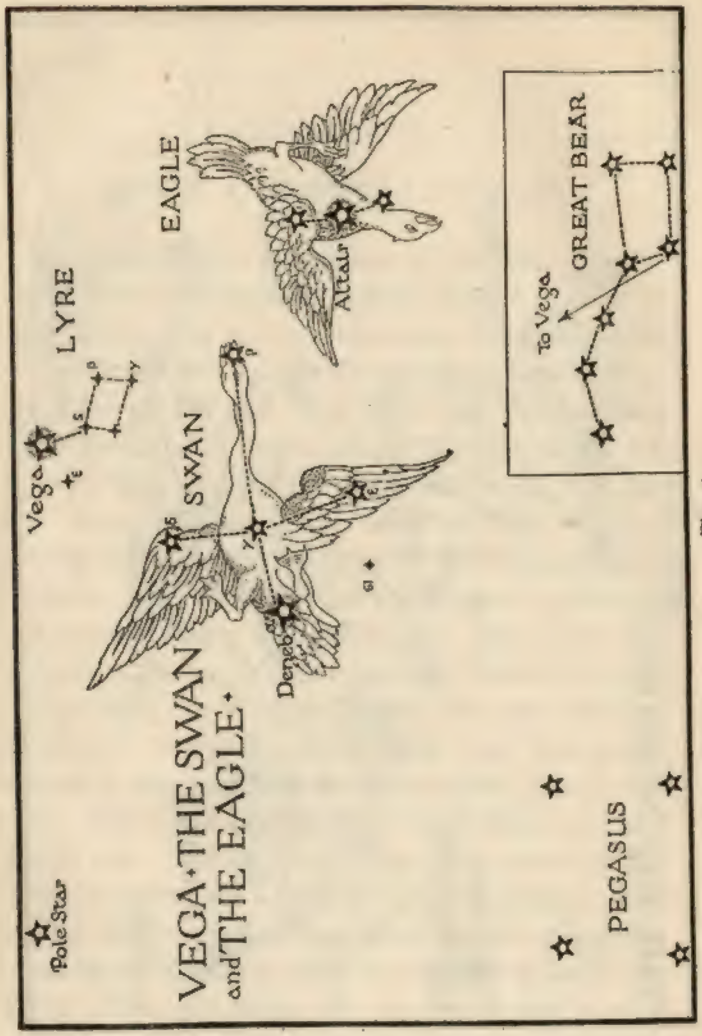


Fig. 5

Perseus [*per'-se-us*], which consists of a line of five stars pointing down towards the horizon and slightly curved, Andromeda being on the hollow side of the curve. β of Perseus, usually known by its name, Algol, the Devil Star, is not one of the line but is away on the hollow side of it. Perseus is rather like a bow, Algol being at the point where the archer holds his bowstring as he draws back the arrow to shoot.

Cepheus, Cassiopeia, Andromeda and Perseus form the Royal Family, and they, like the Bears, illustrate an old story, one in which Pegasus also takes part. Cepheus and Cassiopeia were the King and Queen of Ethiopia, and Andromeda was their daughter, whom Cassiopeia claimed to be more beautiful than the sea nymphs, and to avenge this insult, Neptune, the god of the sea, threatened to destroy their kingdom unless Andromeda was given as a sacrifice to the sea. The unfortunate princess was therefore chained to a rock and a sea monster was sent to devour her. Then Perseus arrived, returning on his flying horse Pegasus from an expedition against some fierce women called the Gorgons. He had with him the head of one, Medusa, and this head had the remarkable power of turning to stone any living thing that looked on it. Perseus there-

fore showed the head to the sea monster, turning it into stone, rescued Andromeda, married her, and thus became one of the Royal Family. Some accounts of the legend are different in detail, but that is a general outline of it. In old maps the star Algol, the light of which goes dim sometimes, is shown in the head of the wicked Medusa.

Fairly high in the western sky there is a brilliant star of the first magnitude, Vega [*ve'-ga*], which is α of the little constellation of the Lyre (Lyra; an ancient musical instrument). This is one of the brightest stars in the sky and there should be no difficulty in finding it, though the Great Bear is shown in Fig. 5 (inset) as a guide to it.

Between Vega and Pegasus, situated in the Milky Way, is the Swan (Cygnus). The stars of this constellation form a large cross, the head of the cross being a first magnitude star called Deneb [*den'-eb*]. The very faint star marked 61 in Fig. 5 is one of the nearest of all the stars, and the first to have its distance measured. Though one of the nearest, it is so far away that light, travelling 186,000 miles *every second*, takes eleven years to reach us.

Nearer the horizon than these two groups, and forming a triangle with Vega and Deneb, is another first magnitude star, with a fainter star each side

of it. This is Altair [*al-tair'*], or α Aquilae, meaning α of the Eagle (Aquila).

This completes our survey of the chief autumn stars. We have the Bears in the north, Cassiopeia nearly overhead, Perseus, Andromeda and Pegasus between east and south, and between south and west are Vega, the Swan and the Eagle.

In WINTER the Great Bear is tail downwards towards the east and Cassiopeia is beginning to descend in the western sky. The remainder of the Royal Family, to the east of south in autumn, have also moved, Pegasus being now low in the west, Andromeda leading upwards from it, and Perseus quite high in the sky. Notice at the southern end of Perseus a tiny but beautiful group of six stars; these are the Pleiades [*ply'-ad-ez*], which belong to the constellation of the Bull (Taurus) and will be mentioned again in a later chapter. Quite near to Perseus and almost at Zenith is a first magnitude star called Capella [*ca-pel'-la*]. It is the chief star of the Charioteer (Auriga), and like Vega is one of the brightest of all the stars. Fig. 4 shows the position of the Pleiades and Capella relative to Perseus.

A line from the Pole Star through Capella leads southward to the most magnificent constellation of

all, Orion [*o-ri'-on*] (Fig. 6), one that is mentioned in the Bible (Job ix. 9, xxxviii. 31). He is shown as

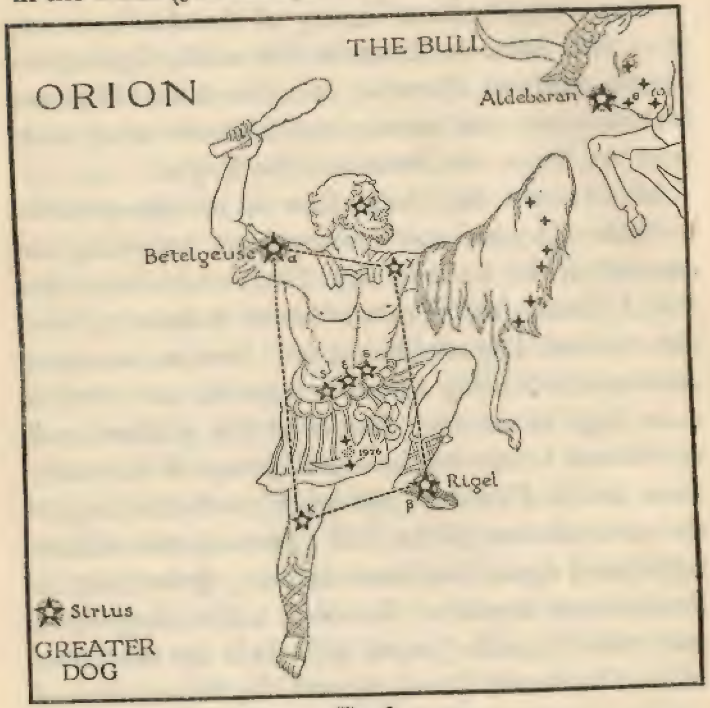


Fig. 6

a hunter facing the Bull, and with his club raised ready to strike. At his right shoulder is a first magnitude star, Betelgeuse [*bet'-el-jooz*], and at his left foot another, Rigel [*ri'-gel*]. Betelgeuse is a

very large star, so large that if our Sun was at its centre we too should be inside. Orion's belt is shown by the three stars in a row, and the stars below it, one of which shines with a hazy light, form the sword. Above and to the right of Orion is a first magnitude star, Aldebaran [*al-deb'-ar-an*], representing one eye of the Bull, while low behind him is yet another, Sirius [*sy'-re-us*], of the Greater Dog (Canis Major). Sirius is the brightest star of all and the meaning of the name is "Sparkling One". The Lesser Dog (Canis Minor), whose brightest star is Procyon [*pro'-se-on*], is higher in the sky and farther behind its owner. There are various stories of Orion, but it appears that he was a giant, and in order to obtain as his wife the daughter of the King of Chios he was commanded to clear the island of wild animals. This he did, and afterwards boasted that he was master of all animals. It is said that as a punishment for his boast he was killed by a scorpion, but being somewhat of a hero was placed in the heavens after death.

Above Procyon there are two more bright stars, belonging to the Twins (Gemini), but these may be identified with more certainty by reference to the Great Bear (Fig. 7), the line joining δ to β pointing to them. The upper one, α of the Twins

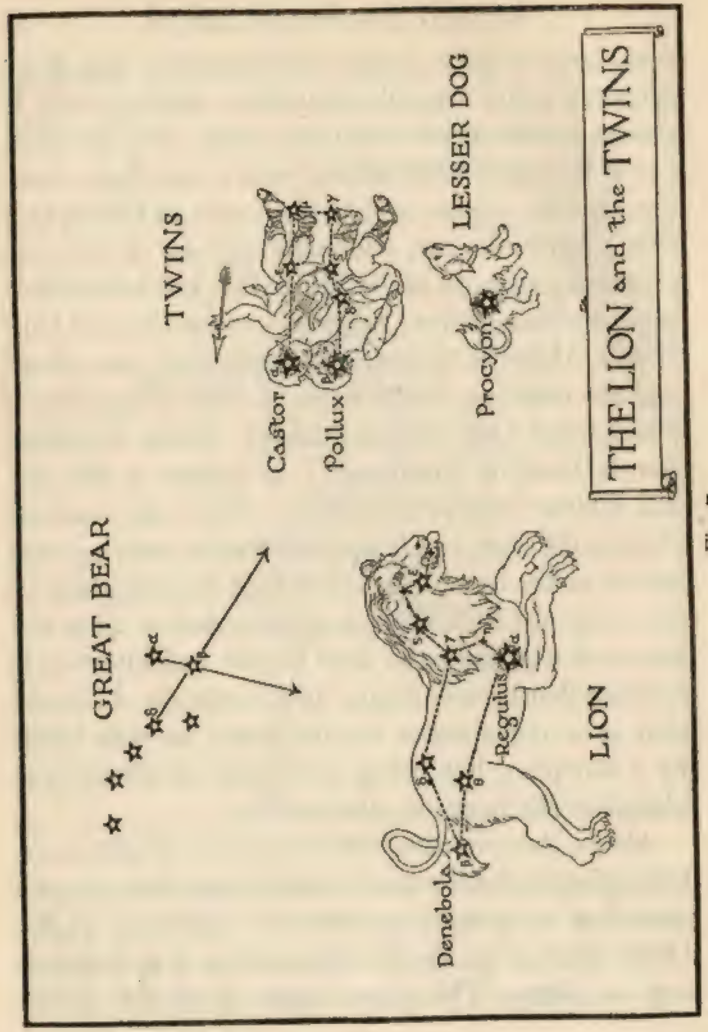


Fig. 7

(α Geminorum), is called Castor, and the lower one, β, is Pollux. In this case β is a little brighter than α, so possibly one of them has changed in brightness since they were given their letters. Castor and Pollux were twin brothers and soldiers. Castor was killed in battle, and Pollux then appealed to the gods that his brother might share his own life. Thus they took it in turns to live on earth, a day at a time, and the gods were so impressed by this brotherly love that they placed both of them in the heavens. As one of their expeditions was against pirates, and on another occasion they were concerned in checking a storm, these two were regarded as the friends of sailors. A ship named after them is mentioned in the Bible (Acts xxviii. 11).

The Great Bear is a guide to another constellation, for if the Pointers are followed away from the pole instead of towards it we come to the Lion (Leo), which will be near the eastern horizon. In the early evening during January it will not have risen, but it can be seen about 9.0 at the beginning of February and from 7.0 at the beginning of March. There is one first magnitude star, Regulus [*reg'-u-lus*], at its breast, a fairly bright star called Denebola [*de-neb'-o-la*] at the tail, and the forepart of the animal is shaped like a sickle.

The winter stars, therefore, consist of the circumpolar constellations the Bears and Cassiopeia, the autumn groups Pegasus, Andromeda and Perseus in the west, while the queen of the night is Capella overhead. In the south Orion faces the Bull and is followed by his dogs, while behind this great hunter, leaping up in the east, is the Lion. High in the sky, between Capella and the Lion, are Castor and Pollux, the "Heavenly Twins". So many bright stars are not seen together at any other time of year.

With the coming of SPRING these brilliants are less in evidence. Orion and his attendants will be found low in the west, beginning to set, while Capella and the Twins, though still prominent, are well past the meridian. The chief constellation at this time of year is the Lion, now high up in the south, having chased Orion, so to speak, out of the sky. The Great Bear is nearly overhead, and may be used as a guide to one of the newcomers in the east. The tail forms a curve, and by continuing this curve we come to one of the brightest stars, one which is unmistakable on account of a slight orange or yellow tinge in its light, Arcturus [*ark-tu'-rus*], or α of Boötes [*bo-o'-tez*], (Fig. 8). Boötes is sometimes described as a herdsman and is also referred to as a bear driver. As the figure represented on some old

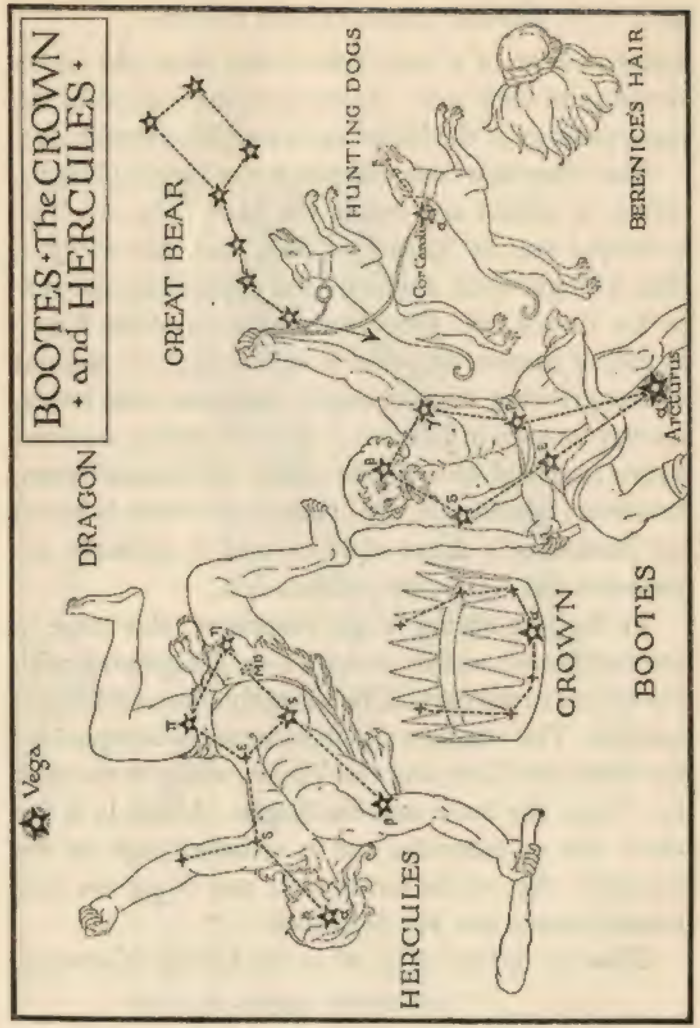


Fig. 8

maps is that of a man behind the Bear, the latter name suits very well. Arcturus is mentioned in the same passage of the Bible[1] as Orion (Job xxxviii. 32).

The other new constellation is the Virgin (Virgo), which is behind and below the Lion (Fig. 9). The principal star is Spica [*spi'-ka*], and this forms a fine triangle with Arcturus and Denebola, the star in the Lion's tail. One representation of the figure is that of Justice, who fled from the earth on account of the growing wickedness of man, and who holds, as may be seen in London at the Old Bailey, a sword in one hand and scales in the other. A different figure, however, is shown in the illustration, which is based on Flamsteed's Atlas of 1729, and it probably represents the Egyptian goddess Isis.

In the late spring Vega reappears, this time in the north-east, and in SUMMER we are greeted with the return in the east of the westerly constellations of autumn. The western sky in summer is occupied by the Bear, the Lion and the Virgin, while in the east are Vega, the Swan and the Eagle. Arcturus is the chief star of summer, and is situated high in the southern sky, while between it and Vega are two constellations not yet described.

Close to Boötes (Fig. 8) is the Crown (Corona),

[1] Authorised version.

Fig. 9

which is easy to identify on account of its horseshoe shape. All but one of its stars are rather faint, and this, together with the lightness of the summer sky, sometimes causes difficulty in seeing the constellation.

Between the Crown and Vega is the large and rather indefinite constellation of Hercules [*her'-ku-lez*], another of the old time heroes. Hercules is commonly referred to as the Kneeler, and the figure is that of a giant kneeling, with one foot on the Dragon's head. The peculiarity of this figure is that we see him upside down. The explanation of this is that since the figure was recorded by the ancients the position of the pole, i.e. the point about which the stars make their daily rotation, has changed, and also the observers were in a lower latitude than we are; they saw the figure the right way up in a northerly direction. This famous hero distinguished himself as a child by crushing to death two serpents, and while still little more than a boy he rid the district of a dangerous lion. His more notable achievements were the twelve difficult tasks known as "the labours of Hercules", one of which was the destruction of the Hydra. This was a terrible monster with a hundred heads, and whenever one head was struck off two more grew in its place, until

Hercules discovered that he could prevent new heads from growing by burning the wound with a hot iron.

One other star to look for in summer is Antares [*an'-ta-rez*], or α of the Scorpion (Scorpio). This will be found, if the horizon is clear, low in the south, and may be recognised by its brightness and reddish colour.

This finishes our exploration of the principal constellations. They are by no means all, and many more will be found in the map of the whole sky given in the endpaper. Once you can recognise the leading ones, as described in this chapter, there should be no difficulty in finding any of the others. To use the map proceed as follows:

The map shows all the constellations that can be seen from this country, but as they are not all visible at the same time a mask is provided to limit the map to the part that can be seen. The mask can be inserted in four ways, corresponding to different times of year, and the first thing to do is to choose the most suitable way. The centre of the circle represents zenith and the edges the horizon, and the easiest way to compare it with the sky is to hold it over your head with the north, south, east and west in the correct directions. Alternatively, hold

the map so that the name of the direction in which you are looking is printed the right way up: the lower half of the circle then represents the sky from horizon to zenith. The dome of the sky is a hemisphere and this cannot be represented correctly on a flat sheet, so the constellations near the edges of the map appear rather spread out sideways. On account of this the mask is not quite accurate at the eastern and western horizons, and conceals stars that will have just risen or are about to set. The spreading out of the stars has, so to speak, carried the end ones over the edge. The astronomers' Latin names are used on the map, but a list of their meanings is included in Appendix II. Very faint constellations are indicated by name only.

Name the stars! Not so difficult after all, and what tales of long ago they have to tell!

CHAPTER III

WANDERING STARS

We saw in Chapter I that the night sky does not present the same appearance all the year round. Owing to the motion of the Earth around the Sun, the stars, in their daily journey across the sky, arrive in any particular position four minutes earlier each night, until at last they are so early that it is not dark enough to see them. Then we found that they all shared in the same movement and among themselves make distinctive patterns, our constellations, which have been the same for many centuries. That is why they are called the "fixed stars", in distinction from the much smaller number of bodies which do not make definite patterns, but are constantly changing their position among the fixed stars. In this chapter we are going to look for wanderers, and try to find out how and why they wander.

Each night at some fixed hour the stars are nearer the western horizon than they were the night before, and below the horizon is the Sun. Thus you

might say they are chasing the Sun and eventually catch it up. Instead of saying that the stars are moving to the right towards the Sun we might say that the Sun is moving to the left among the stars, just as the haystack in Fig. 1 appears to move to the left in front of the distant church. The old time astronomers noticed that the Sun and several other bodies moved among the stars like this and called them "planets", from the Greek word for wanderer, though now the name is used only for those wanderers whose journey, like that of the Earth, is around the Sun. The planets known in those days were Mercury, Venus, Mars, Jupiter and Saturn, and these, with the Sun and Moon, made seven moving bodies. There may be some connection between them and the seven-day week. Our names certainly suggest a Sun's day, a Moon's day and a Saturn's day, and if you look up the French words for the other days of the week you will find a resemblance there too.

The Chaldeans, who lived in what we now call Mesopotamia, carefully observed the stars near the Sun at sunrise and sunset, and divided the sky into the twelve constellations, one for each month, through which the Sun passes. They are called the "Signs of the Zodiac", and are referred to in the

Book of Job as "Mazzaroth". As an aid to memory their names are frequently written like this:

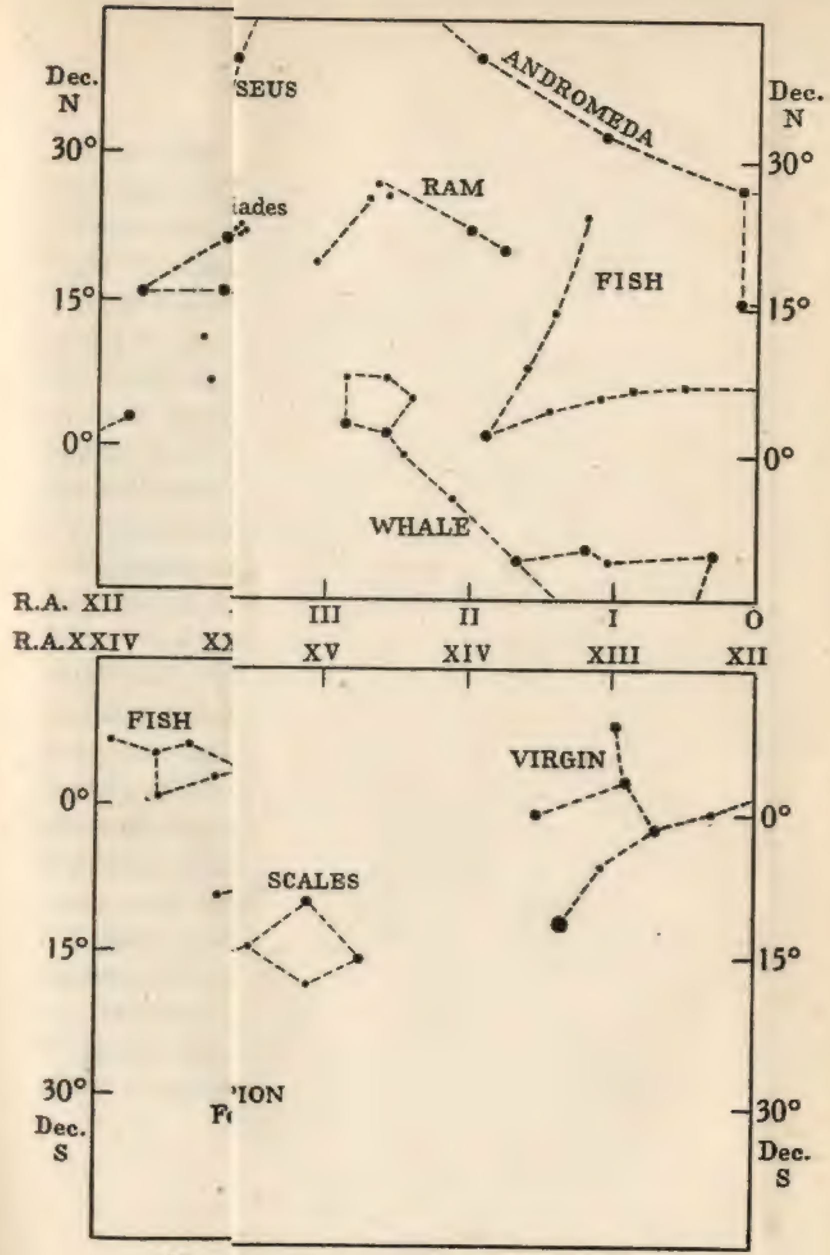
> The Ram, the Bull, the Heavenly Twins,
> And next the Crab the Lion shines,
> The Virgin and the Scales;
> The Scorpion, Archer and the Goat,
> The Man who pours the water out,
> The Fish with glittering scales.

The Ram is the sign allotted to March, the Bull to April, and so on, but actually the Sun is one behind and does not reach the Ram until April. It was mentioned on page 6 that the daily four minutes by which the stars are earlier add up in a year to twenty-four hours *very nearly, but not quite.* Thus they are not in quite the same positions on the same day and at the same hour every year, and in the two or three thousand years that have passed since the Zodiac was invented the tiny differences have added up to a whole constellation, so now the Sun is always a month late and still getting later.

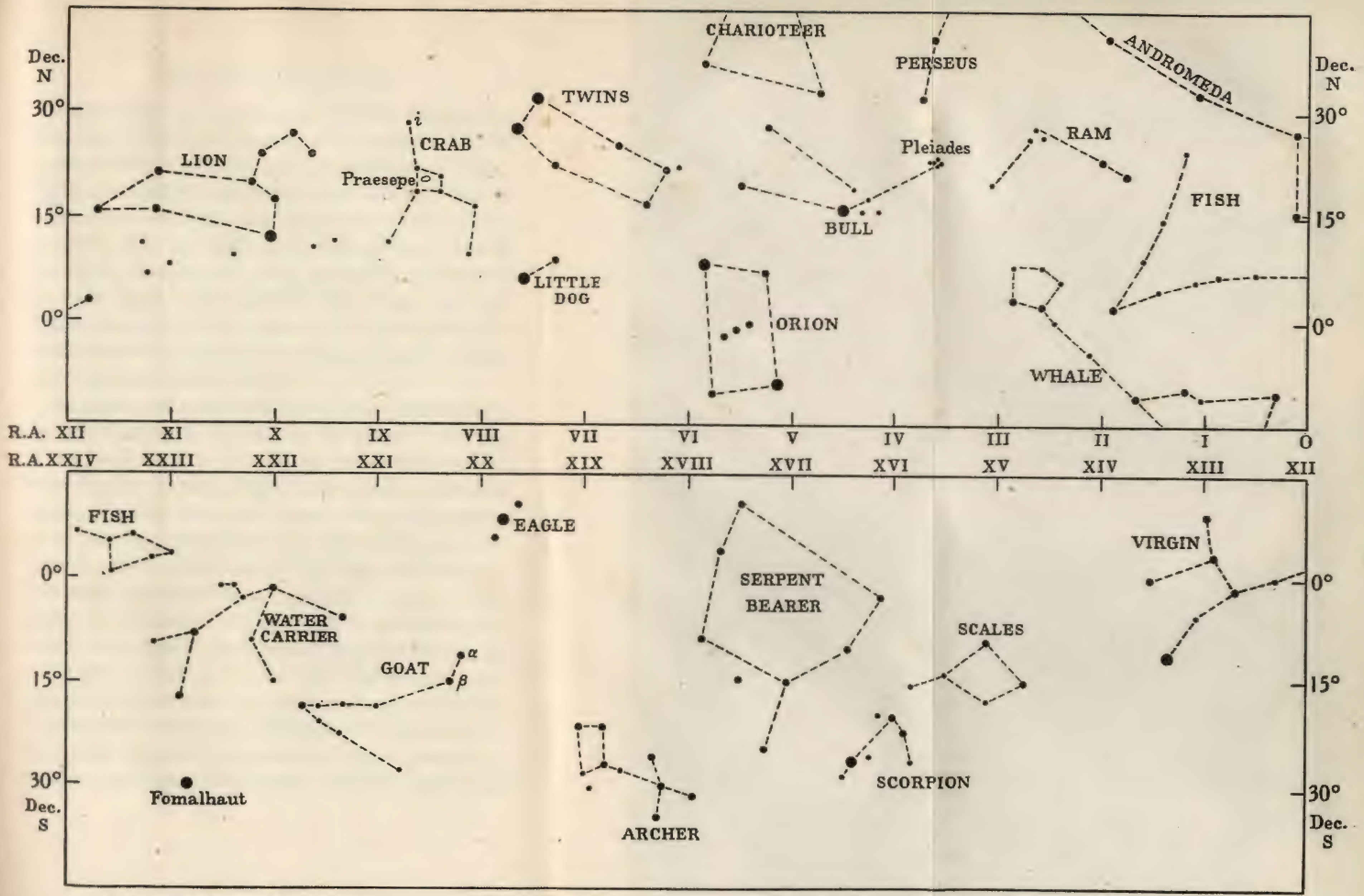
The exact line of the Sun's motion through the Zodiac is called the "ecliptic", and it is an interesting experiment to find out where it is. The Sun itself, of course, is too slow in moving and would be difficult to use for other reasons as well, but the Moon follows a similar path, not quite the same

but near enough, and can be used instead. Fig. 10 is a map of the constellations of the Zodiac, and the first thing to do is to make a tracing of it, so that results can be put in without marking the book. At the first appearance of the young Moon as a thin crescent in the west, compare the stars near it with your traced chart. Make up your mind how the Moon lies among them and then mark the position, with date, on the chart. Do the same thing on as many nights as possible for the next fortnight or more and then join up the line of points obtained. Repeat the experiment the next month, as it is easy to make mistakes the first time. This will give about half the ecliptic, and the other half may be found by watching the Moon again six months later. If you do take positions in two successive months, compare them and try to find out how long the Moon takes to return to the same place among the stars, not taking into account slight differences up or down. This will be the period of revolution around the Earth, which is less than a calendar month.

It should hardly be necessary to explain here the cause of the "phases", or varying shapes of the Moon, as a good diagram illustrating this can be found on an early page of almost any Atlas of the



● Very ınd Dec. explained in the Appendix



● Very Bright • Moderate • Faint

R.A. and Dec. explained in the Appendix

Fig. 10. The constellations of the Zodiac.

World. There is, however, a simple experiment that can be tried by anyone a bit doubtful. Hold a tennis ball at arm's length some distance from a light or window and notice that half the ball is lighted and the other half in shadow. Turn slowly round so that the light is in front of you, then to the right, then behind, then to the left and finally in front again. The lighted half of the ball will appear to vary in shape just as the Moon does, for the ball moving around your head is like the Moon moving around the Earth.

Examine the constellations of the Zodiac regularly and compare them with the chart. You may find a bright star in the sky but not on the chart: it is probably a planet. Mark its position in the same way as for the Moon, on a fresh tracing for preference, and then examine its position at frequent intervals. Each mark must be labelled with the date, and with the name if you happen to know it. If the object is a planet it will be found to be moving; in some cases quickly, in others slowly; sometimes to the right, sometimes to the left. The planets were discovered, of course, by patient observers following their motion among the stars. Another way to recognise a planet, or perhaps it is better to say an aid in recognising one, is that it is less likely than

the stars to be twinkling, and it quite often happens that a planet is shining steadily while all the stars near it are flashing rapidly in and out. Identifying a planet is more difficult than finding it, unless you have an almanack that gives them. The distances of the planets vary, causing their brightness to vary also, but Jupiter and Venus are usually brilliant enough to attract special attention. The latter is never very far from the Sun, so it is necessarily in the west if visible in the evening and its light is very white, with perhaps a slight suspicion of blue about it. Saturn and Mars, though quite conspicuous, are not as bright as the other two, and the light of Mars is a noticeably reddish colour.

Whitaker's Almanack will help you to find the planets. For each month there is a table giving "Rising, Southing and Setting of the Planets", and in this table choose the date nearest to that of your observation and the column of the planet you are interested in. A twenty-four hour day is used in the almanack, so after midday twelve hours must be subtracted to give clock time p.m., and in the summer you must also add one hour to give summer time. If your time of observation is near the southing hour, the planet will be in a southerly direction; if between rising and southing, it will be south-east;

if between southing and setting, then look south-west; if not between rising and setting at all don't look, for it is not to be seen. Perhaps some examples will make this clearer, so suppose it is 8.0 p.m. in winter. A planet rising at 18.0 hours (6.0 p.m.) and southing at 24.0 hours (midnight) will be roughly south-east. One southing at 16.0 hours, and setting at 22.0 hours will be in the south-west, while one rising at 21.0 hours and setting at 9.0 hours next day will be below the horizon and cannot be seen at all. The almanack, therefore, tells you in which part of the sky to look, and then your knowledge of the constellations will enable you to find the steady shining stranger without difficulty.

Watch the western sky particularly, soon after sunset, and the time will come when you will see the evening star shining in the twilight. When you have found it follow its path among the stars, inserting it on your chart every four or five days. For two or three months it will be found to be getting higher in the sky and brighter, and moving to the left among the stars. Then it will stop and turn back, moving to the right rather more quickly, and in a few weeks will be lost in the twilight from which it came. An old Greek name for this evening star is Hesperus. Now if it should be winter, with

its dark mornings, and if you are one of those virtuous people who rise before the Sun, begin to watch the eastern sky in the early morning. A few weeks after the disappearance of Hesperus you will see Lucifer, the morning star (mentioned in the Bible[1], Isaiah xiv. 12), low down just before sunrise. In the succeeding weeks it will move to the right in the Zodiac and get higher and earlier each morning, and then like the evening star will turn back, and become lost in the sunrise. Hesperus and Lucifer can never both be seen during the same period, for in reality they are the same planet, Venus, appearing alternately on opposite sides of the Sun. The reasons for this behaviour are that its orbit, or path around the Sun, is within that of the Earth, and that it moves faster than we do, completing its circuit of the Sun in 225 days. If two trains are running side by side, but at different speeds, and you are a passenger in the slower one, the faster one slowly passes you, just as if it were moving slowly and you not moving at all. Thus a slow moving Venus seen from a stationary Earth would have the same kind of apparent motion as we actually see, so assume that the Earth is stationary and study Fig. 11. When Venus is at 1 it is seen

[1] Authorised version.

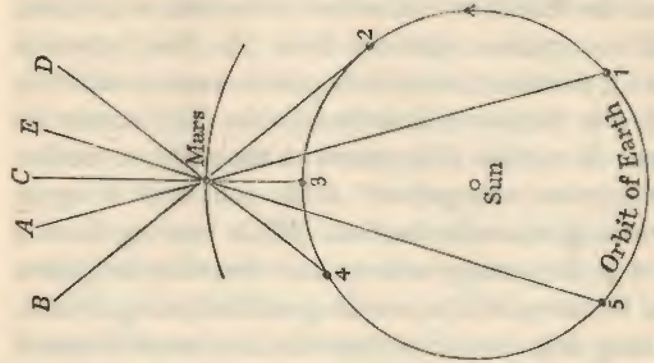


Fig. 12. The motion of Mars

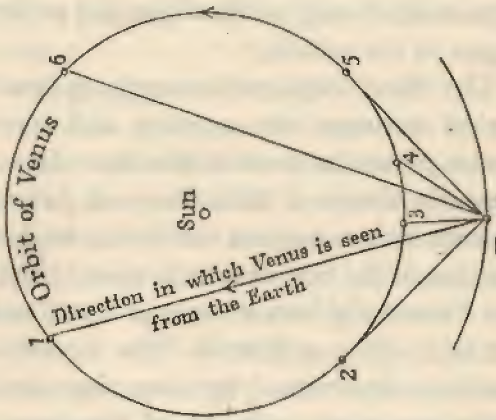


Fig. 11. The motion of Venus

from the Earth in a direction to the left of the Sun, and its apparent distance from the Sun increases until it reaches 2, when it begins to return, and at 3, being in the same direction as the Sun, cannot be seen. At 4 it has reappeared on the right, it reaches "maximum elongation" at 5, and at 6 is again returning towards the Sun. While moving from 1 to 2 it is getting nearer, and therefore brighter, and from 4 to 6 it is receding and becoming fainter. It may help you to picture the motion of Venus if you remember that when watching a friend going round on the hobby horses at a fair he or she will appear alternately to the right and to the left of the organ in the middle.

The above explanation suggests that during the period between the evening and morning stars Venus passes in front of the Sun. In actual fact it is nearly always a little above or below, and only on very rare occasions can Venus be seen crossing the disc of the Sun as a little round black spot. The last "transit of Venus" was in 1882, and there will not be another until 2004. The distance of the Sun has been determined by observing carefully, from two places many miles apart, the exact position of this little black spot on the Sun's disc.

Mercury moves in the same manner as Venus,

but as it is nearer to the Sun and farther from us it is never much out of the twilight. This makes it difficult to see, and only on comparatively rare occasions is it a really noticeable object near the eastern or western horizon. *Whitaker's Almanack* gives the dates on which, weather permitting, it is possible to see it. In the writer's experience the weather has a nasty habit of not permitting, as a clear horizon is essential, and evening mists are very common in this country. There is a legend, a doubtful one, that the great astronomer Copernicus (1473–1543) never saw Mercury in his life, on account of mists rising from the river Vistula, near which he lived.

The remaining planets have orbits outside that of the Earth, and in consequence they are not confined to the eastern and western horizons, but may be found also in the part of the Zodiac that lies to the south, high up in winter and low in the summer. Mars is the one moving most quickly, and sometimes two or three nights are enough to show its motion. Jupiter is much slower, moving only one constellation a year, and every two months is often enough to mark its position on the chart, while Saturn moves so slowly that once a year will do. Like Venus they vary in brightness as their distance

varies, and near the time of greatest brightness there are changes in their apparent motion. If you watch Mars regularly and fill it in on your chart you may be fortunate enough to find it stop its motion to the left, go back a bit, and then resume its normal path eastwards among the stars. Maximum brightness occurs when half way back, as the planet is then at its nearest and is said to be in "opposition". This time the Earth is the faster planet, so in studying Fig. 12 assume Mars to be at rest. When the Earth is at 1, Mars with respect to the distant stars appears to be in the direction *A*, and as the Earth moves to 2 our neighbour moves on to the direction *B*. Following on the numbers 3, 4 and 5, it will be seen that Mars appears to go back through *C* to *D* and then resumes its normal motion as it moves towards *E*. Opposition occurs when the Earth is at 3. The length of the backward path is not as great as the diagram suggests, because Mars is not at rest, but is moving in its orbit in the same direction as the Earth moves.

All the planets outside the Earth's orbit show a similar motion but are much longer in doing it, and although you may be able to detect the backward or "retrograde" motion of Jupiter you are unlikely

to be successful in the case of Saturn. Uranus, Neptune and Pluto, being still farther away than Saturn, are too faint to observe with the naked eye.

Most Atlases of the World have a page devoted to the Solar System, and there you will see the Sun in the centre with the orbits of the planets shown as a series of circles around it. The orbits of the planets are really slightly squashed circles, called ellipses, but there are some bodies, comets and meteors, which have very long narrow orbits with the Sun near one end. In pictures a comet is shown as a bright star with a long shining tail, but it is very rarely that such spectacular ones are seen. Most of these wanderers are so faint that they are not visible to the naked eye, and when a bright one does come it is sure to be mentioned in the newspapers. Some of the comets are known to be periodic, that is they return at regular intervals, while others may be casual visitors from the depths of space, to which they return after a few months near the Sun.

The other bodies, meteors, everyone has seen, for they are the familiar shooting stars, whose whole life, as far as we are concerned, consists of one bright streak across the sky. At certain times

of the year there are showers of meteors, that is to say, a good many in one evening and all coming from the same part of the sky, called the radiant. At the time of a shower it is interesting to watch the sky carefully and see how many you can count in an hour. Meteors are very numerous at the end of July and first half of August, and this happens to be a time when it is not unpleasant to sit out and watch. If you know the constellations well you may be able to spot the exact tracks of the shooting stars through them, and then draw them on a star map afterwards. The lines obtained will point away from the radiant, which in August is in Perseus. There is another well-known shower in the middle of November, known as the Leonids because their radiant is in the head of the Lion. Meteors are really particles of rock flying through space, where from we do not know, and when they get near the Earth the friction of the air is so great that not only do they get hot enough to shine but most of them burn away completely. Only very occasionally do they actually fall to the earth, but when they do there is a kind of explosion, and if a large one fell in a populous place considerable damage would be done. Heat produced by friction is a common experience, for you need only rub a piece of wood with sand-

paper to test that, and some readers may have noticed the heat produced by compression in a bicycle pump, but with thoughts of a motor car radiator in your mind you may wonder why flying through *air* should make the meteor hot. The ordinary motor car rarely travels faster than a mile a minute; a meteor travels at something like twenty miles *a second*, and that makes all the difference.

CHAPTER IV

WITH A TELESCOPE

Everyone is familiar with the common magnifying glass; it is a convex lens, a round piece of glass with carefully made curved surfaces and thicker in the middle than at the edge. Most people also know that if held in the sunlight it concentrates the light and heat to one bright spot where, in summer, a piece of paper will be scorched and may even take fire. This point is called the focus and the distance of it from the lens the focal length. An astronomical telescope consists of two such lenses fixed at opposite ends of a tube, the one nearer the eye being called the eye lens and the far one the object glass. The object glass is the larger of the two and has a long focal length, and it acts like a camera in making a little picture, called an image, at its focus. The eye lens is then used as a magnifying glass to look at this image. We know, from the formation of shadows, that light travels in straight lines, and this fact enables the path of light through a telescope to be shown in a diagram (Fig. 13). The full lines represent rays from the top of the distant object:

they meet opposite *F*, where the image is formed, and then pass through the eye lens and enter the eye as if they came from *A*. The broken lines represent light from the bottom of the object, and they enter the eye as if from *B*. The angle between *A* and *B* is greater than the angle between the original full

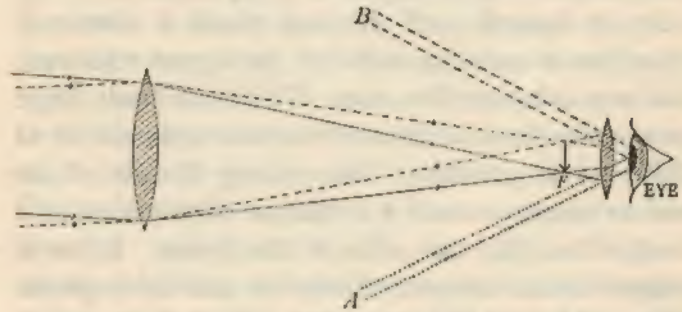


Fig. 13. An astronomical telescope

and broken lines, making the object seem bigger than it would appear without the telescope. Notice also that *A* is at the bottom, so the object when seen through the telescope is not only magnified but appears upside down.

A telescope of this kind can be made from any pair of convex lenses provided that their focal lengths are different, the one with the greater focal length being chosen as the object glass. This should

be fixed at one end of a cardboard tube, such as is used for sending pictures or maps by post, or a tube made from stiff brown paper, and the length of the tube should be a little less than the two focal lengths added together. The eye lens should be attached to another tube just small enough to slide inside the first, in order to focus the telescope, that is to say vary its length until the best result is obtained. Needless to say this will not be a *good* telescope, but any is better than none. To obtain fairly large power the focal lengths of the lenses should be as different as possible. Two young friends of the writer recently made a telescope of this kind at a cost of *3s. 3d.*, the price of the lenses. It has a magnification of twenty diameters and although the edges of bright images appear coloured, or, to use the correct term, it is not achromatic, it shows many of the objects mentioned in this chapter.

An actual astronomical telescope has in place of the eye lens an eyepiece, consisting of two lenses in a short metal tube, and an instrument for ordinary use has four lenses in the eyepiece in order to show things the right way up. Binoculars, or field glasses, consist of two short telescopes side by side, as do the very little ones known as opera glasses, though the latter have as an eyepiece a single concave lens,

thinner in the middle than at the edge. Either of these instruments, or a telescope having an object glass as small as one and a half inches in diameter, may be used for studying the objects given in this chapter. The telescope should be put on a stand of some kind, such as can be devised with Meccano, or with a few pieces of wood and a camera tripod, and if a stand is not forthcoming the telescope must be rested on something. When using binoculars always work against a wall or some other object on which to steady your arms, or else sit in a low chair with your hands resting on the end of a walking-stick. Begin your observations by looking at a star and focusing the instrument; the star ought to appear as one tiny point of light, but if you cannot avoid a round patch of light get it as small as possible. Do not use a star low in the sky for this purpose.

The MOON is our nearest neighbour, a sphere roughly 2000 miles in diameter and 240,000 miles away, and the smallest of instruments will show something of its surface. The best time to observe it is soon after new moon, when it is a crescent, and study it nightly until full. Shadows occur at the boundary of light and darkness, and the irregularities are thereby thrown up in strong relief. Notice first the large dark patches. The ancients

thought they were seas and gave them fanciful names such as "Sea of Tranquillity", but in actual fact they are vast and barren plains. The next

Fig. 14. Map of the Moon

feature which catches your eye is the round spots called craters, from their resemblance to volcanoes. They are probably volcanic in origin, but are very much larger than any known volcano and are not

active now. There are three main types of ring mountains: ringed plains like Plato, where the middle is fairly flat; craters like Tycho, where the middle is a rough hollow, frequently with a central mountain; finally, numerous little hollows without much mountain around them, and most of which are too small to see with binoculars. Ranges of mountains are also to be found, but are rather more difficult to pick up with small instruments. These ranges are named after the mountains on the Earth, such as the Alps, while the names of the ring mountains perpetuate the memory of astronomers and other learned men. Fig. 14 is a diagram showing a few prominent features to look for, and a short description of them follows. Remember that if you have an astronomical telescope the Moon will appear upside down and you must invert the map. Try to draw sometime a map from your own observation.

Alphons is a ringed plain 65 miles in diameter, the mountains forming the ring being 5000 to 9000 feet high. Astronomers can deduce the height of a mountain by measuring the length of its shadow.

Alps. A mass of mountains mainly from 3000 to 8000 feet high, Mt. Blanc (14,000) being its highest peak. A 2-inch telescope will show cutting through these mountains a straight valley 75 miles long.

Apennines. There are four peaks of 12,000 feet and over, the highest being 20,000. This range is steep on the side towards the Sea of Showers. Between the Apennines and the Alps are the Caucasus Mts.

Archimedes is a ring plain, 50 miles in diameter and about 4000 feet high.

Copernicus is probably the finest of the craters, being 56 miles in diameter and having mountains towering 12,000 feet above the central floor. There is a mountain in the middle, and at full moon a number of bright streaks may be seen radiating from this crater.

Plato is a 50-mile ring plain, noted for the rather dark colour of its interior.

Ptolemy is a very large ring, 90 miles in diameter.

Sea of Crises is mentioned here because it is surrounded by mountainous country, almost like a very large ring plain. It is about 280 miles long.

Theophilus. Diameter 64 miles, height 18,000 feet, with a central mountain.

Tycho is another fine crater about the same size as Copernicus. It is in a very rugged area and is the centre of a number of quite long bright streaks, sometimes called rays, which show at full moon.

The Moon is moving among the stars and, of course, passes in front of some of them. It is very interesting to watch the sudden disappearance of

a star when the dark side of the partly illuminated Moon blots it out. The sudden disappearance shows that the Moon has no, or very little, atmosphere, for if there was a layer of air around it the star would fade out gradually. Having no air or water the Moon must be uninhabited, and would not be a pleasant place to land on from a rocket as some people are talking of doing. *Whitaker's Almanack* gives the dates and times of these "occultations", as the disappearances are called, together with the names and magnitudes of the stars concerned. "D" means disappear, and "R" means reappear as the Moon moves away from the star, and the twenty-four hour day (see page 36) is used in the table. Use the telescope or binoculars, and do not bother with stars fainter than about fifth magnitude.

Planets next claim our attention, and the telescope gives another method of distinguishing them from stars. The stars are so far away that a telescope cannot magnify them, but only makes them into brighter points of light; a planet, being nearer, is magnified and shows a small but definite disc. On a clear and moonless night turn your instrument on:

JUPITER, the largest planet, and notice the definite disc. Look carefully for other points of light near it, and under suitable conditions one, two,

three or four will be found, all in a straight line. These are Jupiter's four large satellites, or moons, and their discovery by Galileo early in 1610 was one of the first astronomical observations ever made with a telescope. Make a little sketch of the arrangement of Jupiter and family and look again the next

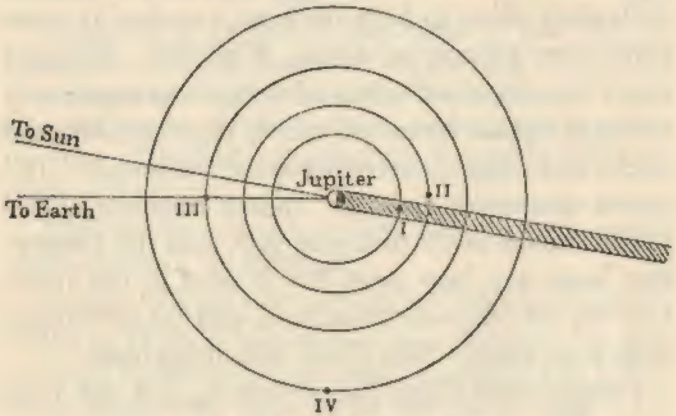


Fig. 15. The Satellites of Jupiter
I. Eclipsed. II. Occulted. III. In transit. IV. Visible.

night: their movements around Jupiter will then be apparent. Make sketches for a number of days, and then if you wish to check the accuracy of your observations you will find the correct "configurations", as the arrangements are called, in *Whitaker's Almanack.* The reason why there are not always four visible is shown in Fig. 15. In their journey

around the planet they may pass behind it, when they are said to be occulted, in front of it, which is called transit, or into its shadow, when they are eclipsed and we cannot see them because they are screened from the light of the Sun and are therefore unable to reflect light in our direction. Stars shine by their own light, but planets and satellites are seen only by reflected sunlight. Jupiter has markings on it, called belts, and seven[1] more satellites, but it takes a good 2-inch telescope to show the belts, and the satellites are so small that it is only with difficulty that astronomers can even detect their presence.

VENUS is not quite as easy to observe but is worth trying. Examine the disc very closely: is it complete? As the orbit of Venus is within that of the Earth, this planet is always more or less in the same direction as the Sun, so stand some distance from an electric bulb or a candle, representing the Sun, and get a friend to move a tennis ball slowly around it. As in the Moon experiment on page 35 phases will be obtained, and it is just possible that the phases of Venus are within the power of your instrument. The cause of the phases is further illustrated in Fig. 16. The best time to try with a small instrument is when the evening star is moving

[1] Including two recently discovered.

towards the Sun, or the morning star moving away from it, as Venus at that time is looking almost as large as it can and also, being a crescent, is readily distinguishable from an ordinary round disc. Under these favourable conditions there should be no difficulty; bright twilight will improve the definition.

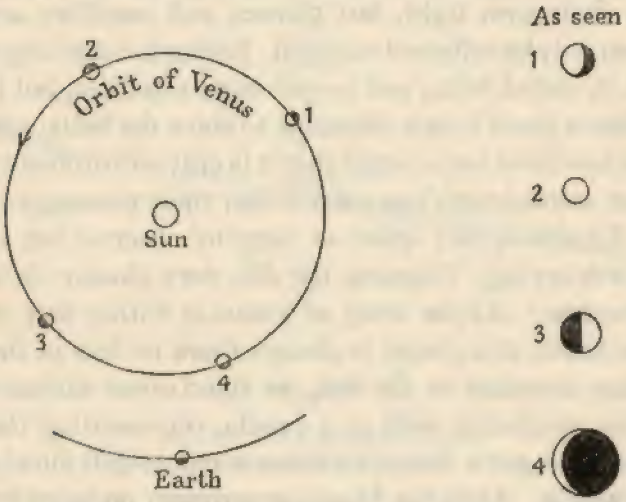


Fig. 16. The phases of Venus

Of the other planets MERCURY shows phases like Venus, but on account of its small size and low altitude in the sky there is no hope of seeing them with small instruments. SATURN is the planet with rings, but with a telescope less than a 2-inch you

are not likely to see anything of them except a slight oval appearance of the disc. MARS has only a disc to show, as its two satellites are very small ones.

Leaving the Solar System for a time we now turn to stellar objects, the first being the little group of

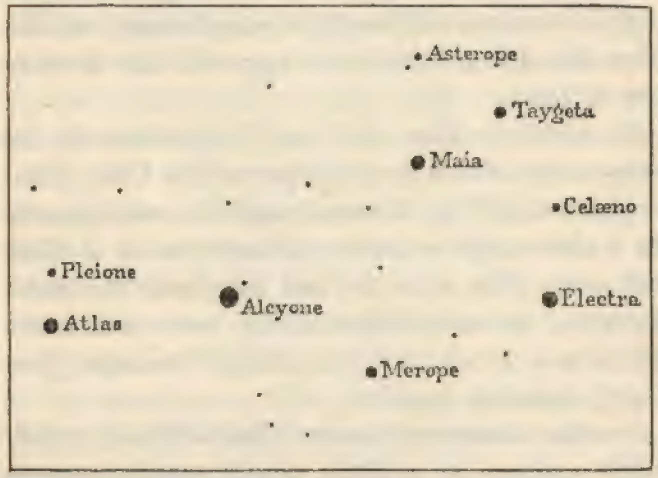


Fig. 17. The Pleiades

stars called the Pleiades (page 19). Look at the group and count them; use the telescope and count again. This is a beautiful subject for small instruments, as the number increases from the usual six to twenty or so. Fig. 17 gives the names of the principal members, which, according to old legends,

represent Atlas and Pleione and their seven daughters. Although normal sight sees six stars, old records mention seven, and it is thought that Pleione has diminished in brightness. There are two old stories accounting for the lost Pleiad, one being that whereas six daughters married gods Merope married a mortal and her light was dimmed, and the other that Electra faded with grief at the destruction of Troy.

Between the Lion and the Twins there is the rather insignificant constellation of the Crab (Cancer), shown in Fig. 10, consisting of a small square. On a clear night examine this square: it is filled with stars. The stars are not merely in the same direction, but are comparatively near each other and form a STAR CLUSTER called Praesepe [*pre-se'-pe*], meaning beehive.

Another cluster quite easy to find is N.G.C. 869*, which appears as a little bright patch between Perseus and Cassiopeia (Fig. 4). Notice carefully the shape when seen with the telescope, two round patches just touching each other. Cluster M 13† in Hercules is barely visible to the naked eye and is not really an object for small telescopes, but as it

* No. 869 in the New General Catalogue.

† No. 13 in Messier's Catalogue.

is a very famous one it is worth looking for, and is therefore shown in Fig. 8.

Quite near to the Perseus cluster, in the constellation of Andromeda (Fig. 4), is another luminous patch, N.G.C. 224, more generally known as M 31. This is not a cluster but a NEBULA, which is a huge mass of gas shining either by its own light or by that of the stars mixed with it. The telescope or opera glass brightens the patch and shows it to be oval in shape and shining like a little silver cloud. An interesting thing about it is its great distance, for its light, travelling 186,000 miles a second, takes about 900,000 years to reach us. Many nebulae[1] are much farther away than this. Another famous nebula is N.G.C. 1976 below the belt of Orion (Fig. 6), and this also is just visible to the naked eye. With ordinary binoculars it is rather disappointing, but with moderate telescopes, say 3-inch upwards, it is a finer object than M 31.

For observations of this kind, and indeed, for stellar objects generally, it is important to choose nights when there is no moonlight, and to keep away from artificial lights, as it does not take much to overpower the feeble rays from a nebula. Scientists believe that the stars, including our own

[1] Nebulae: plural of nebula.

particular star, the Sun, have been formed out of nebulae. In course of millions of years the nebula breaks up and condenses into stars, almost as a cloud of steam condenses into drops of water.

The middle star of the Great Bear's tail has a faint companion referred to in Chapter I as "the rider", and it is worth looking at this pair with a glass. Here we have two stars, Mizar [*mi'-zar*] the brighter and Alcor the fainter, close enough together to be passed casually as one, and this introduces another type of object called DOUBLE STARS. These two companions in space are really too far apart to be classed as a true double star, but a more powerful telescope shows that Mizar itself consists of two stars which do form a true double. There are a great many of these objects in the sky, some coloured, others moving slowly round one another, and some, called multiple stars, in which one or both components is itself a double. The great majority of the double stars are beyond the reach of the small instruments at our disposal, but there are a few objects of this class worth looking at.

Just west of the first magnitude star Aldebaran (Fig. 6) is a double called θ Tauri, one of a numerous group of stars known as the Hyades [*hi'-a-dez*]. As an aid in picking it out from among its nearest

neighbours the group seen with a $1\frac{1}{4}$-inch telescope, together with the position of Aldebaran, is shown in Fig. 18. If in doubt of the meaning of the name θ Tauri, see Appendix II. Another easy double is ε Lyrae (Fig. 5); in this case a small instrument separates it into two, and a powerful instrument will separate each of those into two, so you are really looking at a quadruple star.

Fig. 18. The region of θ Tauri, as seen through a $1\frac{1}{4}$-inch telescope

α Capricorni (Fig. 10) is like Mizar, with a naked eye companion, and β of the same constellation is double with binoculars, the fainter star being bluish in colour. These stars are quite easily found by following the line formed by the three principal stars of the Eagle. π_5 Orionis (Fig. 6) also has a near companion, which is worth looking at on account of the orange tint in its light.

In case any readers have the use of moderately

good telescopes the following list of double stars is given. It is possible to separate some of them with a $1\frac{1}{2}$-inch telescope, but they are not really suitable for observation with anything less than a 2-inch.

Mizar	β Cygni	
Cor Caroli (Fig. 8)	61 Cygni	Fig. 5
δ Cephei (Fig. 4)	β Lyrae	
ι Cancri (Fig. 10)	ζ Lyrae	
ν Draconis (end paper, next D of Draco)		

Castor (Fig. 7) is a famous double star, one of the revolving kind, but is much more difficult to separate than any of the above list. Close revolving pairs are called Binary Stars.

One of the foregoing list is of interest to the naked-eye observer, and although the following experiment is not "with a telescope" β Lyrae may be described conveniently at this point. Look carefully at the whole group forming the constellation of the Lyre and make a note of the brightness of β compared with its neighbours. Repeat the observation regularly for several days, and you will find that your results are not all the same, for β Lyrae is a VARIABLE STAR. Sometimes it appears a little brighter than the next star, γ, and at other times it is definitely fainter. δ Cephei is also variable, but the most famous star of the class is Algol, or β Persei (Fig. 4). This star will usually be found

shining with its normal brightness, but every three days it is considerably fainter for about three hours. *Whitaker's Almanack* gives the dates and times when Algol can be seen at minimum. The explanation of the behaviour of Algol is that it is a revolving double star, one of the pair being very faint, and once in three days the faint component passes in front of the bright one and cuts off its light.

Much pleasure may be obtained with a small instrument without turning it to any particular object. There are parts of the sky that are very rich in stars, and it is well worth while to look at them with a telescope. The Milky Way is specially worth attention in the constellations of the Eagle, the Swan and the Charioteer, in the last of which a number of small clusters and nebulae are dotted about and may prove just visible. Another bright spot that should not be missed is Berenice's Hair (Fig. 8), about which there is an old story. Berenice was an Egyptian queen who promised to sacrifice her hair to the gods if the king was successful in war. He was, and the hair was duly cut off and placed in the temple, but the next day it disappeared. The king was very annoyed about the disappearance, and to pacify him one of his wise men pointed to this star-spangled patch of sky and told

him that the gods were so impressed by the beauty of the hair that they had placed it in the heavens.

A very bright star can look beautiful through a small telescope, as it sometimes twinkles with coloured light and may give coloured streaks if the instrument is shaking slightly. These effects are sometimes better if the telescope is slightly out of focus, and as they depend upon the condition of the atmosphere they are better some days than others.

The SUN has been left until last as the observation of it is in some respects difficult and dangerous. There is considerable risk of injury to the eyesight if the Sun is observed without adequate protection from its light and heat, which are much intensified by a telescope. There are two methods of observation, directly through dark glass, and by projection. For the direct way do not work near the middle of the day, but within two or three hours of sunrise or sunset. The dark glass cover for the telescope, which is usually but not necessarily at the eye end, must be very dark, much darker than dark spectacles, though spectacles will be found an aid in pointing the telescope at the Sun. Dark celluloid or gelatine must on no account be used at the eye end, as the heat concentrated by the lenses may be sufficient to burn a hole in such substances. Densely smoked

Fig. 19. Observing the Sun by projection.

glass, which can be conveniently prepared with a candle-flame, can be used when the Sun is low in the sky, though the lenses of the instrument must not be smoked. In the projection method the telescope is turned towards the Sun and a sheet of white cardboard held a few inches from the eyepiece. A bright spot of light will appear on this screen, and by altering the focus an image of the Sun can be obtained. It is also necessary to have a second piece of cardboard fixed to the eyepiece to protect the screen from direct sunlight. Fig. 19 shows two youthful observers applying the method to a 3-inch telescope. Whichever method you use, look carefully for any black marks on the Sun's disc: if you find any, move the telescope slightly and see if they move across the disc. If they do, they are due to dust on the lenses; if they move with the disc, they are sunspots. What we see of the Sun's surface is something in the nature of hot and shining clouds at a temperature of about 10,000° F. You will realise how hot this is if you remember that water boils at 212° F., and iron melts at 2700° F. Sometimes holes appear in this surface, many of them large enough to drop the whole Earth in, and we see them as black spots. Make a drawing showing as accurately as you can the positions of any spots

visible. This is where the projection method has the advantage, for if you draw on the screen a circle just the size of the image and rule a series of numbered lines across it, you can determine the position of a spot by noting which line or lines it is near. Put the drawing away for a day or two and then look again at the Sun: the spots, if still there, will have moved. This is because the Sun, like the Earth, is rotating on its axis, the time taken to make one rotation being twenty-five days.

One other thing before leaving the subject of the Sun. If an eclipse occurs, do not fail to look at it; the almanacks and newspapers always give due warning. Watch the Sun through dark glasses or smoked glass, and you will see a round object passing in front of it. This is the Moon getting just between the Earth and Sun, and if it does not cover the Sun completely, the phenomenon is called a partial eclipse of the Sun. A total eclipse, when the Sun is completely covered, is a rare occurrence in any one place, for although such events do actually happen fairly frequently they can be seen only from a very small part of the world, and astronomers wishing to study them are sometimes forced to travel to very remote spots. The last total eclipse visible in England was in 1927, and the next will be in 1999.

CHAPTER V

WITH A CAMERA

Photography is a very important aid to the astronomer, so it is interesting for a beginner in astronomy to make use of his camera. Many people lay up their motor cars for the winter, but there are a great many more who pack up their cameras until the return of brighter days. There is no need for you to pack up yours, for in this chapter there are a number of suggestions for interesting and instructive experiments with it. Any camera can be used. As a general rule work with the largest stop, as the variable hole near the lens is called, and in the case of a star photograph develop your films or plates rather longer than you would an ordinary picture. If your developing is done for you, do not fail to tell the chemist or photographer just what to expect. Some kind of stand for the camera is desirable, but if no stand is available you can always place the camera on a table or wall with a block of wood or a brick to tilt it against. Avoid the neighbourhood of lights as much as possible, for in making a long exposure the light of a nearby street

lamp may blacken the film, especially if there is any mist about.

Choose a clear moonlight night and fix up the camera, facing the Moon, in a place where it need not be moved for a couple of hours. Arrange for the Moon to be on the left of the picture, and to do this it should appear in the *right*-hand side of an ordinary reflecting view finder. Every quarter of an hour take a time exposure of one second, working the shutter with a cable release if you have one, and on developing the picture you will find not one Moon but several, all in a line. This shows that the Moon is moving across the sky, and, indirectly, that the Earth is rotating on its axis. Another way of doing this is to leave the shutter open all the time, so that instead of a number of separate images there is a continuous streak. Fig. 20 shows the track obtained by leaving the shutter open for an hour and a quarter. If you take a photograph of this kind, measure carefully the length and width of the track. You know how long it took the Moon to move the length of the track, so you can easily work out how long it would take to move the width, which is equal to its apparent diameter. You will be surprised how quickly the Moon does move over its own diameter.

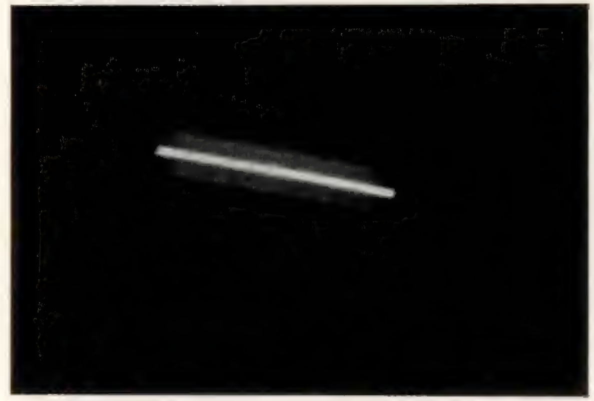


Fig. 20. Track of the Moon.

Fig. 21. Circumpolar stars.

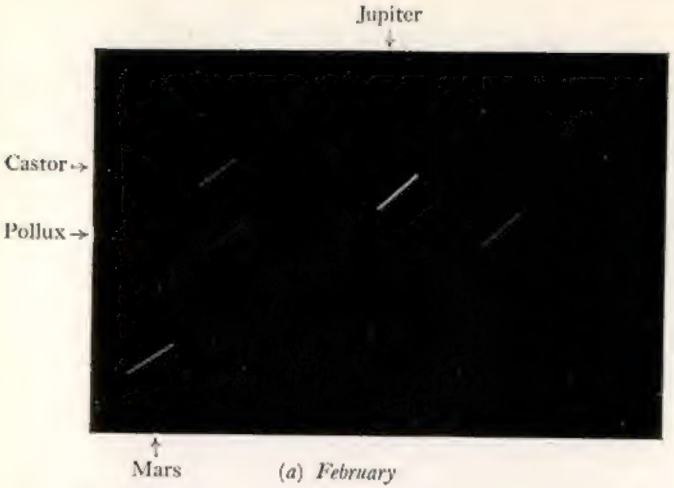
The Moon shines by reflected sunlight, and if for any reason the sunlight is obstructed it will grow dim. This does happen sometimes when the Sun, Earth and Moon are in a straight line, with the Earth in the middle and the Moon in the Earth's shadow. This is an eclipse of the Moon, and when one occurs set up the camera as before and take 1 second exposures every quarter of an hour. Increase the exposure to 3 seconds when the Moon is half obscured and to about 5 at mid-eclipse. The series of images on this photograph will show how the curved shadow of the Earth gradually moves over the disc of the Moon. Why is the shadow curved? This experiment serves to illustrate the fact that the Earth is round. An eclipse of the Sun may be taken in the same way, but using the smallest stop and highest speed (i.e. shortest exposure), and giving rather less than normal development.

The Moon sometimes passes close to a planet or bright star, and is said to be "in conjunction" with it. Conjunctions with the planets are given in *Whitaker's Almanack.* When this occurs take a photograph of the Moon, giving an exposure of 30 seconds, which is rather too much for the Moon but is necessary to give the planet or star a chance to show itself. Change the film and take another

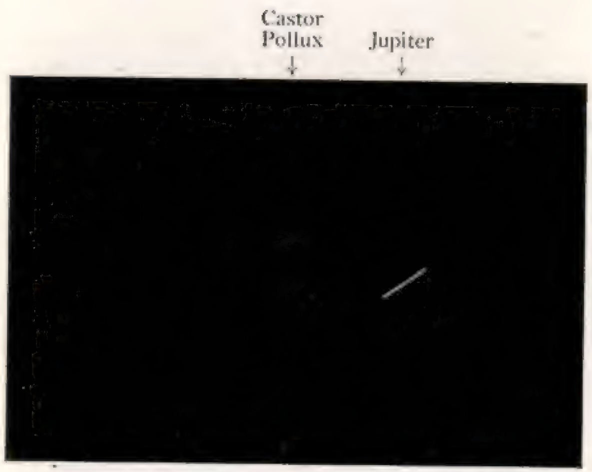
photograph about two hours later. After development place the second negative on top of the first so that the star or planet images coincide: the Moon images will not coincide, for in the two hours interval our satellite has covered a small part of its journey around the Earth, and has therefore moved a little to the east relative to the slow moving planet or fixed star.

The rotation of the Earth can be shown by means of star trails, as well as by the Moon. Set up the camera facing some bright stars in a southerly direction and take two photographs, one of two minutes and the other a fairly long exposure, say half an hour. The short exposure shows how fast is the movement of the stars in the southern sky, for a definite trail is formed in two minutes. In the second photograph notice whether the tracks are straight or curved, and measure them and see if they are all of the same length. In general they are curved, and lines nearer the common centre of the curves are shorter than the outside ones. In Fig. 22*a* the track of Castor is shorter than that of Mars.

The ideal way of showing the Earth's rotation is to point the camera towards the Pole Star and take as long an exposure as possible, in any case not less than two hours. This time the curved tracks



(a) *February*



(b) *April*

Fig. 22. The motion of the Planets, 1931.

show themselves to be parts of concentric circles (Fig. 21) and definitely demonstrate how the northern stars go around the Pole Star. The Pole Star itself is not quite at the pole, for if it were it would give just a bright dot instead of forming part of a very small circle. The exposure for Fig. 21 was $4\frac{1}{2}$ hours, using a $3\frac{1}{2} \times 2\frac{1}{2}$ Ensign plate camera.

The camera may be used to detect the motion of the planets. Take a photograph of the region including the planet, giving an exposure of anything from five to twenty minutes, and take another of the same area in a few weeks. Fig. 22 *a* shows Jupiter and Mars near the Twins in February 1931, the photograph being an exposure of 15 minutes with the Ensign camera. Fig. 22 *b* is of the same area the following April, taken with a $2\frac{1}{4} \times 1\frac{3}{4}$ Vest Pocket Kodak, exposure 20 minutes. Mars has moved right out of the picture, and the Castor-Pollux-Jupiter triangle has changed in shape. By placing the negatives one over the other and making the star trails fit exactly, the motion of Mars and Venus can sometimes be detected after an interval of a single day. This experiment on planets is particularly interesting, as it illustrates the astronomer's method of detecting moving bodies. The new planet

Pluto, discovered in 1930, was found by comparing two photographic plates.

Shooting stars are sometimes bright enough to show on a photograph and are worth trying for. When these objects are expected, as in August or November, the latter for preference, point the camera towards the radiant, open the shutter and leave it for a while. The star trails in the photograph will be curved and parallel, while a meteor trail, if any, will be straight and probably not parallel to the star trails.

From *Whitaker's Almanack* find when Algol is at minimum and take a photograph of Perseus at that time. Take another when Algol is normal. The length of exposure does not matter much, but a quarter of an hour is suitable, and the same exposure should be given in both cases. A comparison of the negatives will leave no doubt of the variability of the Devil Star. The Algol trail should be compared with the neighbouring trails on the same negative rather than with the same trail on the other, as the two negatives may not have had the same amount of development.

The next experiment is to try and use the camera and telescope together. Fig. 23 shows a $1\frac{1}{4}$-inch telescope and an Ensign camera mounted on a

Fig. 23. Apparatus for photography of the Moon through a telescope.

Fig. 24*a*. The Moon, through a small telescope. With $3\frac{1}{4} \times 2\frac{1}{4}$ Ensign, actual size.

Fig. 24*b*. With V.P.K., actual size.

board, and it is essential that they should be so mounted to keep them in line. In the apparatus illustrated Meccano strips were used to hold the telescope at the correct height, and the universal head to the tripod, though not absolutely necessary, was undoubtedly very useful. On the far side two strips were arranged so that when an object was viewed through their upper holes it was in the field of view of the telescope. Direct the telescope to the Moon and focus it in the usual manner. Set the camera for distant objects, that is to say focused for infinity, and then place it in position behind the telescope. The slightest vibration will spoil the photograph, so it is better not to use the camera shutter for making the exposure, and essential not to work in a draughty place. Make sure that the apparatus is pointed correctly at the Moon, hold a piece of cardboard in front of, but not touching, the object glass of the telescope, open the shutter, and then wait for at least a minute without touching any part of the apparatus. It should then be quite steady, and you make the exposure by moving the cardboard for not more than one second, and not closing the shutter until the cardboard again intercepts the Moon's light. Although the telescope was focused correctly for the eye, it may be that it is not correct

for the camera, giving a photograph not as sharp as it ought to be. If this happens take two more photographs, focusing as before, but then shortening the telescope in the first case and lengthening it in the second by a small amount, say about an eighth, or not exceeding a quarter, of an inch. One of your three photographs ought to be successful. This trouble does not occur when a plate camera with a ground-glass focusing screen is used, for the best possible image can be obtained before the plate is inserted. Fig. 24 shows examples of such photographs of the Moon.

The Sun may be photographed in the same way, but it is not as good a subject, because the only markings are sunspots and you are hardly likely to get these on account of over exposure. To reduce the amount of light entering the telescope you should cover the object glass with a piece of cardboard having a small hole in the middle, and in making the exposure use the camera shutter working at its highest speed. Be careful in developing, as the image of a bright object such as the Sun increases in density, i.e. blackness, very quickly.

When astronomers are going to photograph the sky their star camera is attached to a telescope on a special type of mounting called an equatorial. This

mounting is such that the telescope and camera will follow the stars as they move across the sky, so that exposures of many hours may be taken. For obtaining a large photograph of a small area another type of camera is attached to the eye end of the telescope, and a second telescope is fixed to the first for use as a finder. The following is done by clockwork, with an observer at the finder to see that the machine is working at exactly the right speed. With a suitable mounting, such as the equatorial shown in Fig. 19, it is possible to follow a star by hand, the rod that the boy is holding being for the purpose, but that is difficult and rather beyond the scope of this book.

CHAPTER VI

ABOUT BOOKS

This is the most difficult chapter to write, as there are so many books dealing with astronomy and it is hard to pick out just a few. No attempt is being made to pick out the best books, but only to give a little information about several good books in order to help you to find some further reading when you have come to the end of this volume.

There are three books in Benn's Sixpenny Library, and these are mentioned first on account of their low price. *The Earth, the Sun, and the Moon* and *The Stars*, both by Prof. George Forbes, are quite general descriptive books for the beginner, while *Astrophysics* by Dr W. M. Smart is more advanced and deals mainly with the actual nature of the stars.

For a modest shilling there is a small descriptive book, *The Night Sky* by A. D. Merriman (Oxford Press), which gives further details of the sun and planets but otherwise shows a good deal of overlap with this one.

A book on astronomy has been added to Pitman's Science in Everyday Life series, price 2*s.* 6*d.* *Wonders of the Universe*, by H. E. Taylor, covers quite a wide field of study and is well illustrated. It is suitable for use in schools, and the writer has kept in mind its relation with other school subjects. There are sets of exercises on each chapter.

Earth and Sky by C. H. Dobinson (Black, 4*s.*) was written as a school text-book, but at the same time is quite suitable for the general reader. The first chapters are concerned with the history of astronomy, the bulk of the book is descriptive, and the last two chapters deal with the Earth and form an easy introduction to Geology, or the science of rocks. The book is profusely illustrated, and a special feature is the large number of questions for the reader to think out, together with many suggestions for "things to do" and books to read.

Our Wonderful Universe by C. A. Chant, published by Harrap at 5*s.*, is another descriptive and well-illustrated book. It is mainly intended for young people, but will be found interesting to any who are seeking an elementary knowledge of astronomy.

The Spangled Heavens by Lawrence Edwards (Gerald Howe, Ltd.) is yet another small book for young people. Though perhaps not as compre-

hensive as the other two, which is no disadvantage in a children's book, it is very simply written and should be appreciated at an earlier age. There is a foreword by Sir Frank Dyson.

The Stars in their Courses by Sir James Jeans (Cambridge, 7*s.* 6*d.*) is a book written for the general reader by one of the leading scientists of the day. It is an expansion of a series of wireless talks given a year or two ago. The illustrations are numerous and good, and there is a guide to the constellations and star maps of the northern and southern hemispheres. This is one of the best modern books, if not the best, and is very good value.

Through Space and Time is a rather larger volume by Jeans (Cambridge, 10*s.*), but it is not devoted wholly to Astronomy. The history of the Earth and its life will be found in the early chapters, and the book then works outwards through space. It is the substance of one of the annual series of talks arranged for juvenile audiences by the Royal Institution.

Illustrated books for the general reader are very numerous, the following being a few of the more recent ones. The Astronomer-Royal, H. Spencer-Jones, is the author of *Worlds Without End* (English Universities Press, 5*s.*), which therefore comes from

the pen of the professional. All cinema goers will know Will Hay, but they may not know that he is a distinguished amateur astronomer who has written *Through My Telescope* (Murray, 3*s.* 6*d.*). *The Story of Astronomy* by Draper & Lockwood (Allen and Unwin, 12*s.* 6*d.*) is an American book recently published in this country. *Astronomy* by W. M. Smart is one of the up-to-date and well written "Pageant of Progress" series of books published by the Oxford University Press at 4*s.* 6*d.*

Handbook of the Heavens by Bernhard, Bennett and Rice (McGraw-Hill, 15*s.*) is a very useful American book of the same type as the one you are now reading. It is definitely intended to be a practical guide, but is larger and more comprehensive and not directed to young people in particular. During the war it may be difficult to obtain, but if a copy can be found it will be very suitable for those who have exhausted the possibilities of *A Guide to the Sky* but wish to continue their practical studies.

Perhaps the best popular astronomy book ever written is now over sixty years old, and it is well worth an inquiry at the local library or seeking in a second-hand bookshop. This is *The Story of the Heavens*, by Sir Robert Ball. The book is a large

one, very well illustrated, and deals with the whole subject quite fully, although, of course, it does not contain accounts of recent discoveries and theories.

Another book that may be obtainable from your library is *The Splendour of the Heavens*, published in parts by Hutchinson some years ago. This is a very comprehensive work, written by various authors, containing nearly 1000 large pages and packed with illustrations. At the end of the book there are numerous tables and charts useful to amateur astronomers. Remainder copies of this book sometimes turn up in good bookshops. Used copies can be bought through second-hand dealers, and these may be in two volumes instead of one, which on account of the great size of the work is rather an advantage.

Astronomy Without a Telescope by Maunder, and *Evenings with the Stars* by Mary Proctor, are two other quite good books now out of print. The former is described by its title; the latter is a guide to the constellations, with accounts of the old legends illustrated by them and descriptions and photographs of objects of interest.

As a work of reference *Whitaker's Almanack*, published annually at 6*s*., is almost indispensable. The frequent references to it in this book render

description unnecessary, except to mention that it contains several hundred pages of general knowledge in addition to astronomical tables.

An A.B.C. Guide to Astronomy by H. P. Hawkins (Simpkin, Marshall, Hamilton, Kent & Co.) is also of use for reference, as it is a dictionary of astronomical names and allied subjects.

A revolving star map or *Planisphere* is a desirable piece of equipment. Two sizes are published by George Philip; the smaller one (3*s*.) is quite a handy size, but the larger (6*s*.) is much clearer and on the whole is better value. The star map at the end of this book can be arranged to show the positions of the constellations on several different dates: Philip's *Planisphere* can be set for any hour of any night of the year.

The same firm also publish a star map in book form, *The Stars at a Glance*. Besides the general maps, including the southern stars, there are charts showing the aspect of the sky for each month, several pages of general information, and a map of the Moon.

The Times gives an astronomical column at the beginning of each month, and this is very helpful as a means of knowing when special phenomena, such as eclipses, are due to occur. There is also a

map showing the constellations and positions of the planets for the coming month, and by seeing this paper regularly you may be able to do without an Almanack. *The Children's Newspaper* has a weekly astronomical column which also gives coming events and is very instructive.

This book has come to an end. "Now what shall I read?" That is a very difficult question for a stranger to answer, but the writer hopes that the foregoing pages will be of some assistance. Just one last word. Keep a diary of your observations. An ordinary ruled diary is hardly suitable, as many spaces would not be used, and the ones you did use would not be large enough. A thick exercise book with fairly large pages and a good cover is more suitable, and a "Nature Note Book" interleaved with drawing paper is better still. Writing out your observations may seem a lot of trouble at the time, but it is well worth while and you will find pleasure in reading your notes years afterwards.

Since the foregoing chapter was written there have appeared two small books that I can highly recommend. *Astronomy for Night Watchers* by J. B. Sidgwick (Faber, *5s.*); the first half is descriptive, and the second observational with many detailed constellation maps. *First Steps in Astronomy* by P. F. Burns (Ginn, *5s.*); very instructive, with numerous indoor exercises.

APPENDIX I

THE GREEK ALPHABET

The individual stars of a constellation are distinguished by Greek letters, usually in order of brightness, and the full reference to a star is its letter followed by the Genitive of the constellation name (see Appendix II).

α	Alpha	ν	Nu
β	Beta	ξ	Xi
γ	Gamma	ο	Omicron
δ	Delta	π	Pi
ε	Epsilon	ρ	Rho
ζ	Zeta	σ	Sigma
η	Eta	τ	Tau
θ	Theta	υ	Upsilon
ι	Iota	φ	Phi
κ	Kappa	χ	Chi
λ	Lambda	ψ	Psi
μ	Mu	ω	Omega

APPENDIX II

NAMES OF CONSTELLATIONS

The following list gives the Latin names of all the constellations visible in England and which are mentioned in this book or shown on the star map.

The Genitive form is used when the name refers to an individual star, e.g. Regulus is α Leonis, or alpha of the Lion.

The English equivalent is the meaning in common use, and not necessarily the literal translation of the Latin word.

Where no English equivalent is given, it means that the name is that of a person, e.g. Orion.

The page is given when the constellation is mentioned in the text.

Name	Genitive	English	Page
Andromeda	Andromedae	—	14
Aquarius	Aquarii	Water Carrier	33
Aquila	Aquilae	Eagle	19
Aries	Arietis	Ram	33
Auriga	Aurigae	Charioteer	19
Boötes	Boötis	Herdsman	24
Camelopardalis	Camelopardalis	Giraffe	
Cancer	Cancri	Crab	58
Canes Venatici	Canum Venaticorum	Hunting Dogs	
Canis Major	Canis Majoris	Greater Dog	21
Canis Minor	Canis Minoris	Lesser Dog	21
Capricornus	Capricorni	Goat	33
Cassiopeia	Cassiopeiae	—	12
Cepheus	Cephei	—	12
Cetus	Ceti	Whale	
Coma Berenices	Comae Berenicis	Berenice's Hair	63
Corona	Coronae	Crown	26
Corvus	Corvi	Raven	
Crater	Crateris	Cup	
Cygnus	Cygni	Swan	18
Delphinus	Delphini	Dolphin	
Draco	Draconis	Dragon	12
Eridanus	Eridani	(Name of a river)	
Gemini	Geminorum	Twins	21
Hercules	Herculis	—	28
Hydra	Hydrae	Water-snake	
Lacerta	Lacertae	Lizard	
Leo	Leonis	Lion	23
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Lepus	Leporis	Hare	
Libra	Librae	Scales	33
Lynx	Lyncis	Lynx	
Lyra	Lyrae	Lyre	18
Monoceros	Monocerotis	Unicorn	
Ophiuchus	Ophiuchi	Serpent Bearer	
Orion	Orionis	—	20

Name	Genitive	English	Page
Pegasus	Pegasi	Winged Horse	14
Perseus	Persei	—	17
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Piscis Australis	Piscis Australis	Southern Fish	
Puppis	Puppis	Stern (of a ship)	
Sagitta	Sagittae	Arrow	
Sagittarius	Sagittarii	Archer	33
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Serpens	Serpentis	Serpent	
Taurus	Tauri	Bull	19, 21
Triangulum	Trianguli	Triangle	
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Ursa Minor	Ursae Minoris	Little Bear	10
Virgo	Virginis	Virgin	26

* 'Scorpii' sometimes used.

APPENDIX III

THE SOLAR SYSTEM* AND CERTAIN STARS†

Name and symbol		Distance from Sun in millions of miles	Period of revolution around Sun	Diameter in miles	Period of rotation on axis	Number of satellites
Sun	☉	—	—	864,000	25⅓ days	—
Mercury	☿	36	88 days	3,000	88 days	0
Venus	♀	67	225 "	7,600	225 days‡	0
Earth	⊕	93	1 year	7,927§	23 h. 56 m.	1
Mars	♂	142	1 yr. 322 d.	4,200	24 h. 37 m.	2
Jupiter	♃	483	12 years	88,700§	About 10 h.	11
Saturn	♄	886	29 "	75,100§	10 h. 14 m.	9
Uranus	♅	1783	84 "	30,900	About 10¾ h.	4
Neptune	♆	2794	165 "	33,000	15 h. 40 m.	1
Pluto	–	3666	248 "	Rather smaller than the Earth‡	Unknown	—
Moon	☽	From Earth 239,000 miles	Around Earth 27⅓ days‖	2,160	27⅓ days	—

Name	Distance: As a light journey	Distance: In millions of miles	Diameter in miles	Remarks
Sun	8 m.	93	864,000	—
Sirius	8·6 yr.	51,000,000	1,380,000	The apparently brightest star
Proxima Centauri	4·27 "	25,000,000	61,000	The nearest known star
Betelgeuse	190·00 "	1,120,000,000	250,000,000	A very large star
Van Maanen's Star	12·8 "	75,000,000	7,800	A very small star

* Prepared from the *Handbook of the British Astronomical Association.*
† Prepared from Jeans' *Astronomy and Cosmogony.* ‡ Uncertain.
§ At the Equator. ‖ With respect to the stars. New moon to new moon is 29½ days.

APPENDIX IV

RIGHT ASCENSION AND DECLINATION

It was explained on p. 5 that the stars occupy the same positions in the sky four minutes earlier each night, and this is because the Earth rotates on its axis in 23 h. 56 m., ordinary clock time. Astronomers' clocks are set to go twenty-four hours in this period, i.e. they gain four minutes a day, and are said to keep Sidereal Time. If a star is exactly south at a certain time by the sidereal clock, it will be there again at the same time the following night, and, in fact, every night, as the daily four minutes difference is being allowed for by the clock. The sidereal time at which an object is due south is called its Right Ascension and is used to fix its direction in space. The direction is not completely fixed, however, by this one measurement.

Imagine a piece of wire bent at right angles in the shape of a letter L. If one arm of the L were pointed at the Pole Star and rotated, the free end would trace out in the sky a semicircle, called the Equator, which is, by the way, that part of the sky which is seen directly overhead by people living at the Equator of the Earth. The second measurement required to fix the direction of a star is its distance north or south of the Equator, expressed in degrees along a line directly towards or away from the Pole Star. This measurement is called Declination.

Just as a map of England shows lines of longitude and latitude, so do star maps show R.A. and Dec., and this enables the positions of planets and other bodies to be fixed on the map, and hence among the stars. *Whitaker's Almanack* gives the R.A. and Dec. of the planets at weekly intervals.

Example 1 (using Fig. 10). Suppose that the position of a planet is given to be R.A. 20 h. 20 m., Dec. 16° S. Find R.A. XX at the margin of the map, and move on one-third of the way to XXI. All points vertically below this one will have R.A. 20 h. 20 m. as required. Dec. 16° S. will be just below the 15° at the margin, and the planet is therefore horizontally opposite this point as well as on the vertical line already found, i.e. it is close to the star β of the Goat.

Example 2 (using the star map at the end of the book). Find position 7 h. 50 m., Dec. 25° N. The R.A. is just less than 8 hours, so the position will be a little to the right of the line joining VIII to the centre of the map. The Dec. is a little less than 30°, so the position is also a little below the smaller 30° circle, i.e. just below Pollux. The larger 30° circle refers to Dec. S.

APPENDIX V

OBSERVATIONS FOR EACH MONTH

CONSTELLATIONS. The following are visible all the year round and are not given in the monthly lists: the Bears, the Dragon, Cepheus, Cassiopeia. The monthly lists apply to the first three or four hours after dark and include only the most prominent constellations.

OBJECTS OF INTEREST. Objects for the telescope are not mentioned when they would be too high or too low in the sky to be studied conveniently. Thus although the nebula in Andromeda can be found any night from August to March, in December you would have to lie on your back to turn a telescope on it, so it is not included in the list for that month.

The more difficult double stars are not given in these lists.

PLANETS. See *Whitaker's Almanack* for favourable opportunities of observing these.

ECLIPSES. The following[1] will be visible in the British Isles. The Sun: 1942, Sept. 10; 1945, July 9; 1949, April 28; 1951, Sept. 1; 1952, Feb. 25. The Moon: 1942, Mar. 2, Aug. 26; 1943, Feb. 20, Aug. 15; 1945, Dec. 19; 1946, June 14, Dec. 8; 1949, April 13, Oct. 7; 1950, April 2, Sept. 26; 1952, Feb. 11, Aug. 5.

January.

Constellations: Pegasus, Andromeda, Perseus, the Charioteer, the Bull, Orion, the Dogs, the Twins.

Objects: the Pleiades; nebula in Orion; doubles Mizar, θ Tauri, π_5 Orionis; variable Algol.

February.

Constellations: Pegasus, Andromeda, Perseus, the Charioteer, the Bull, Orion, the Dogs, the Twins, the Lion.

Objects: Pleiades, Praesepe; nebulae in Andromeda and Orion; doubles Mizar, θ Tauri, π_5 Orionis; variable Algol.

March.

Constellations: Andromeda, Perseus, the Charioteer, the Bull, Orion, the Dogs, the Twins, the Lion.

Objects: Pleiades, Praesepe, cluster in Perseus; nebulae in Andromeda and Orion; doubles Mizar, θ Tauri, π_5 Orionis; variable Algol.

April.

Constellations: Perseus, the Charioteer, the Bull, Orion, the Dogs, the Twins, the Lion, the Virgin, Boötes.

Objects: Praesepe, cluster in Perseus; variable Algol.

[1] Selected from Hutchinson's *Splendour of the Heavens.*

May.

Constellations: the Twins, the Lion, the Virgin, Boötes, Hercules, the Lyre.

Objects: Praesepe, cluster in Hercules; double ε Lyrae; variable β Lyrae.

June.

Constellations: the Lion, the Virgin, Boötes, Hercules, the Lyre, the Eagle, the Swan. Look for Antares low in the south.

Objects: double ε Lyrae; variable β Lyrae.

July.

Constellations: Boötes, Hercules, the Lyre, the Eagle, the Swan, Pegasus. Look for Antares low in the south west.

Objects: doubles Mizar, α and β Capricorni; variable β Lyrae.

Perseid meteors at the end of the month.

August.

Constellations: Boötes, Hercules, the Lyre, the Eagle, the Swan, Pegasus, Andromeda.

Objects: cluster in Perseus; nebula in Andromeda; doubles Mizar, α and β Capricorni; variable β Lyrae.

Perseid meteors.

September.

Constellations: Boötes, Hercules, the Lyre, the Eagle, the Swan, Pegasus, Andromeda, Perseus.

Objects: clusters in Perseus and Hercules; nebula in Andromeda; doubles Mizar, α and β Capricorni; variables Algol, β Lyrae.

October.

Constellations: Hercules, the Lyre, the Eagle, the Swan, Pegasus, Andromeda, Perseus.

Objects: Pleiades, clusters in Perseus and Hercules; nebula in Andromeda; doubles Mizar, ε Lyrae, α and β Capricorni; variables Algol, β Lyrae.

November.

Constellations: the Lyre, the Eagle, the Swan, Pegasus, Andromeda, Perseus, the Charioteer, the Bull.

Objects: Pleiades; doubles Mizar, ε Lyrae, θ Tauri; variables Algol, β Lyrae.

Leonid meteors.

December.

Constellations: the Lyre, the Swan, Pegasus, Andromeda, Perseus, the Charioteer, the Bull, Orion.

Objects: Pleiades; doubles ε Lyrae, θ Tauri, π_5 Orionis; variables Algol, β Lyrae.

APPENDIX VI

SOUTHERN STARS

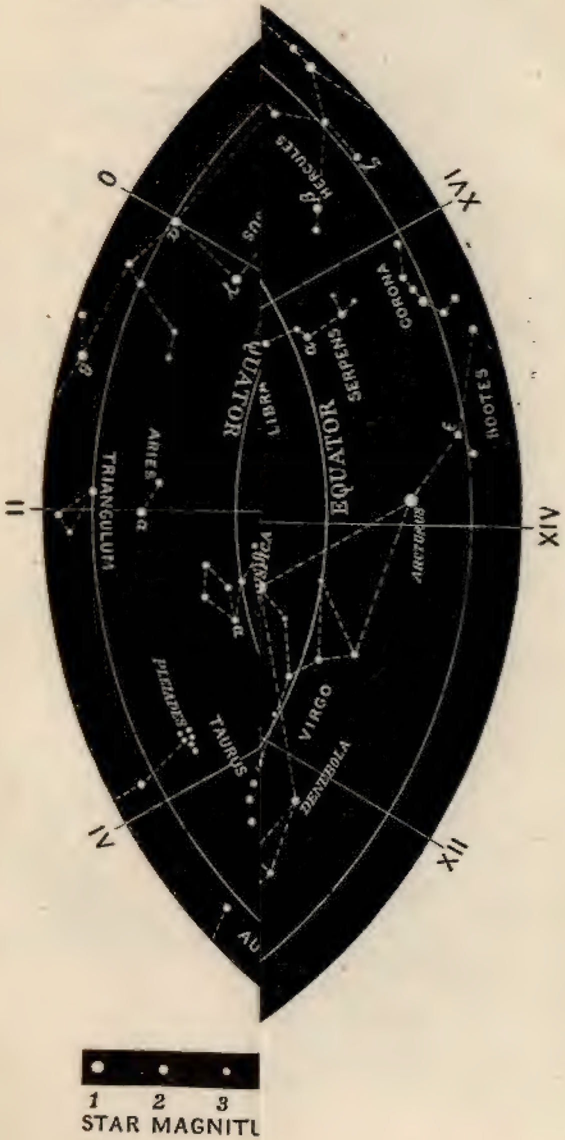
In Chapter 1 it was pointed out that there are some stars that never rise in the British Isles and can only be seen from places much farther south. A map of these stars is included here, in case any readers should travel to the southern hemisphere.

Constellations which we now see in the southern sky, such as Orion and the Lion, will then appear to the north of Zenith and upside down. It may be that the Sun, Moon and Planets will be in the north also (depending on how far south of the Equator you go); if that is the case, remember that their daily motion from east to west will be from right to left, and wherever right and left are used in this book with reference to the motion of these bodies they must be interchanged. They will also appear upside down.

The northern circumpolar constellations are not visible from the southern hemisphere, but those distant from the south pole not greater than, say, Canopus will always be visible as south circumpolar stars. There is no south pole star, but note that the pole is about midway between Achernar and β Centauri.

The following are a few objects of interest, selected from *Norton's Star Atlas*; Right Ascension and Declination are given for objects not named on the map. *Double stars:* γ Leporis and γ Crucis are fairly easy, while α Centauri is very fine but more difficult. *Clusters:* ω Centauri (R.A. 13 h. 24 m., Dec. 47° South); 47 Toucanae (0 h. 22 min., 72° S); M 19 (16 h. 59 m., 26° S); M 23 (17 h. 54 m., 19° S). *Nebulae:* M 20 (17 h. 59 m., 23° S) is the famous "Trifid nebula", but is not very good for small instruments. M 8 (18 h. 01 m., 24° S), the "Lagoon nebula", is a combination of clusters and nebulae. The Greater and Lesser Magellanic clouds (Nubecula Major and Minor) are bright fields of stars. The Coal Sack, between α Crucis and β Centauri, is a starless patch believed to be due to some dark matter between us and the bright part of the Milky Way in which it lies.

The Southern Sky
extended to 40° Nor
of the Equator



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The Southern Sky extended to 40° North of the Equator

[The Roman numerals round the edge refer to the Right Ascension, the numbered circles to Declination. See Appendix IV.]

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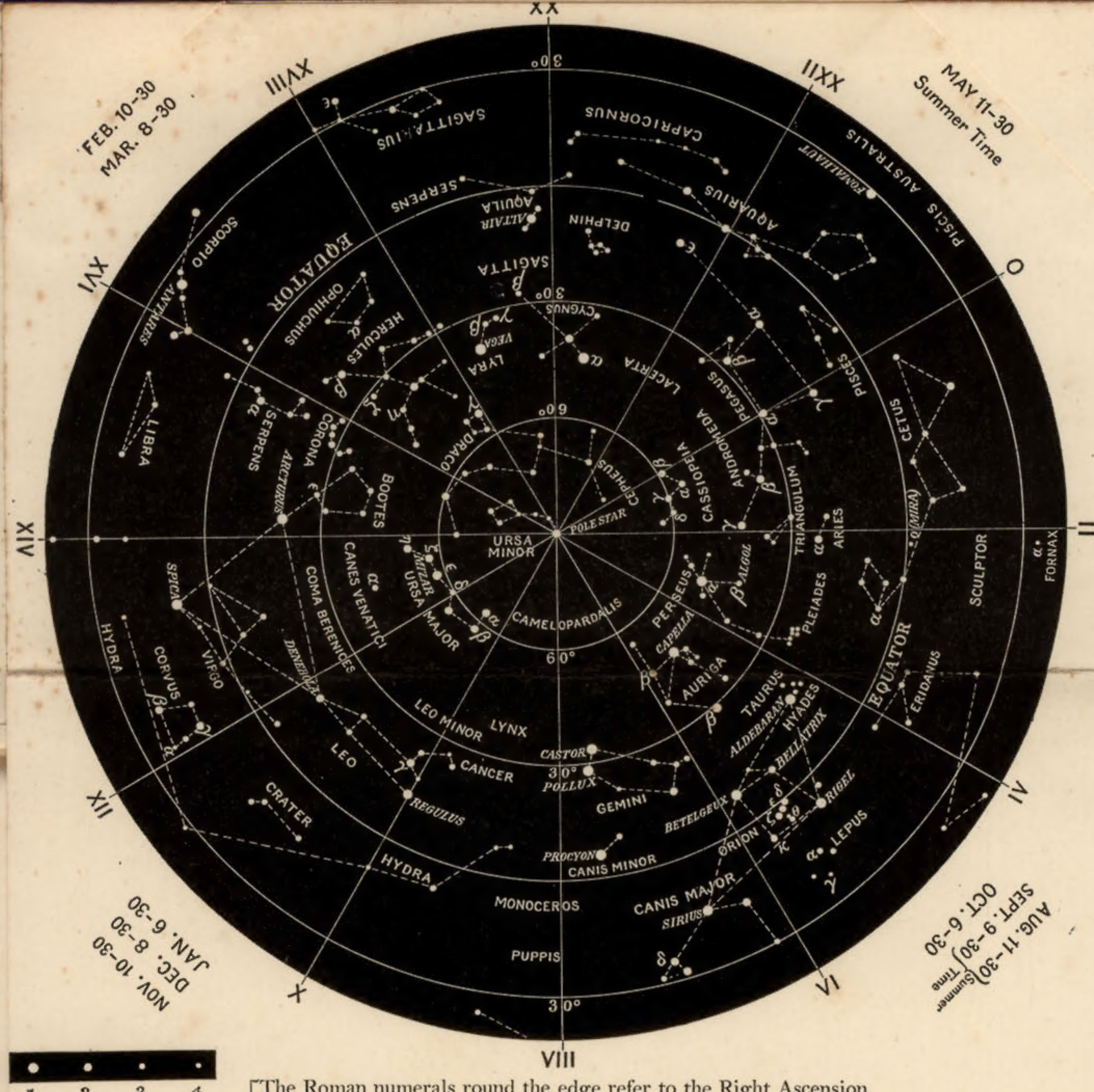

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STAR MAGNITUDES

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